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QUARANTE-TROISIÈME VOLUME

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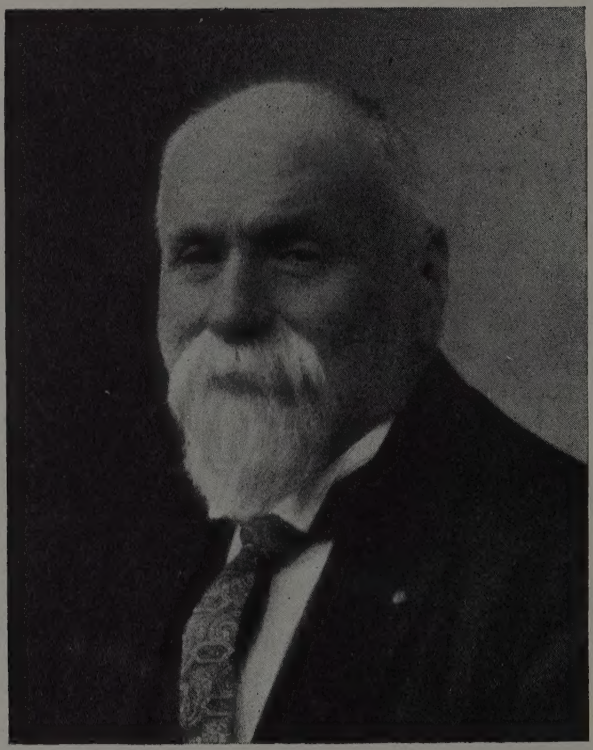

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C'est un grand entomologiste français qui disparaît.

THE SOIL ARTHROPOD FAUNA IN A FARM AT GIZA, EGYPT (1)

(with 22 Text-Figures and 10 Tables)

by AHMAD HASSANAIN EL-KIFL, PH.D.,

Plant Protection Department, Faculty of Agriculture, Cairo University.

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PART VII : MAGNITUDE AND VERTICAL DISTRIBUTION OF OTHER INSECT ORDERS. — I. Introduction. — II. Procedure. — III. Results and discussion (1, Hymenoptera; 2, Thysanoptera; 3, Lepidoptera; 4, Homoptera; 5, Hemiptera; 6, Orthoptera; 7, Neuroptera; 8, Psocoptera). — IV. Summary. — V. Acknowledgments. — VI. References.

(1) Parts I-III has been published in this Bulletin, Vol. XLI, 1957, pp. 231-268.

PART IV : MAGNITUDE AND VERTICAL DISTRIBUTION OF THYSANURA

I. INTRODUCTION

The status of soil Thysanura among other soil Arthropods, was illustrated by MORRIS (1922), THOMPSON (1924) AND EDWARDS (1929). CAMERON (1925-1926) gave some information about these insects in the soil. The activities of thysanuran insects in the soil were discussed by JACOT (1940). STRICKLAND (1944) stated that this order is largely saprophagous in habit, and recorded that the function of the soil forms was not fully understood. He referred to *Japyx* as having shown a tendency to eat tender root cortex in laboratory experiments, but may likely become a pest if their normal food supply becomes exhausted. KÜHNELT (1955), on the other hand, referred to this genus as predator while explaining the general function of Thysanura in the soil.

In Egypt, the writer (1957) discussed the status of the soil arthropods as a whole, the magnitude and vertical distribution of Coleoptera in the soil of a farm at Giza. Presently, the status of Thysanura in this district will be explained.

II. PROCEDURE

The present experiment began in April 1951 and ended at the end of March 1952. It was carried out in the soil of a farm at Giza where six fields, designated (A) to (F), were selected for faunal examination. The first four fields (A to D) were light clay and the other two (E and F) were clay loam. Samples were obtained by a core, four inches in diameter and were taken off to a depth of fifteen inches below the soil surface. Each sample was divided into four strata, viz : 0 to 3 inches, 3 to 6 inches, 6 to 10 inches and 10 to 15 inches. One hundred samples were obtained from each field during the various months of the year.

The method of sampling, the way of dividing the sample into strata, the process of extracting the fauna by the flotation method, the mechanical analyses of fields examined, their botanical censuses and the meteorological conditions of the district were all discussed in a previous paper published by the writer (1957).

III. RESULTS AND DISCUSSION

A. Total Thysanura

1. Means per acre per annum

Thysanura actually composed a very comparatively large fraction of the soil insect fauna. Table I shows the means per acre per annum of thysanuran fauna in fields examined together with their percentages both in total insects and in total

Arthropods. These means and percentages in total insects are illustrated by Figure 1. The means, though fluctuated greatly from field to field, they were clearly higher in clay loam soils (fields E and F) than in light clay soils (fields A to D). The highest mean in the latter soil type was 3.500.000 specimens per acre per annum, while it was 2.115.000 specimens in the former one. The widest range met with was from 300.000 to 7.100.000 specimens in field (D) while the narrowest was from nil to 3.000.000 specimens in field (C).

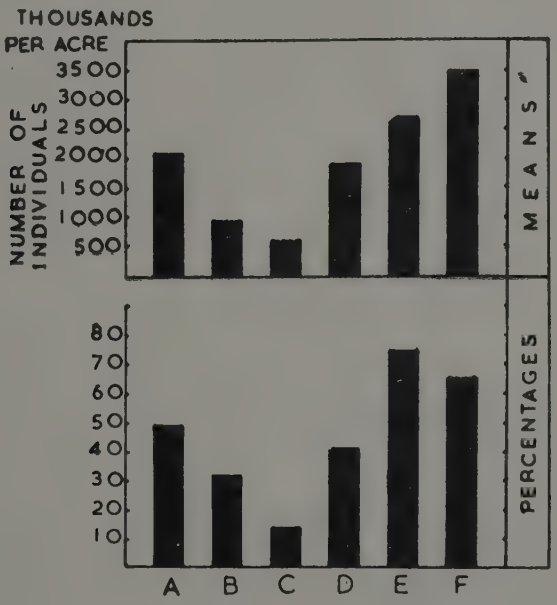

FIG. 1 : Means per acre per annum and percentages, in total insects (A to F, fields examined).

Thysanurans constituted a large amount of the insect soil fauna, particularly in the clay loam soils where their percentages ranged from about 66 to 75% of the total insects or about 55% of the total Arthropods (Table I). Their percentages in light clay soils ranged from about 14 to 49% of the total insects or from about 6 to 27% of the total Arthropods. The difference in magnitude between the two soil types may be due to proper conditions in the clay loam soils such as humidity, continuous irrigation, and suitable air spaces. These conditons seem to be more suitable for movement and mating. The lower percentages and means in fields (B) and (C) might be due to unsuitable temperature accompanied by dryness which dominated under wheat in field (B) and under fallow in field (C), as will be shown by Figure 3.

TABLE I

Means per acre per annum in thousands and percentages of soil Thysanura *in total insects and in total Arthropods*

	Fields examined					
	A	B	C	D	E	F
Means of total Arthropods	13185	7150	10725	7240	4970	6315
Means of total insects	4320	2935	4220	4655	3615	5340
Means of total Thysanura	2115	935	595	1930	2710	3500
Percentages of Thysanura in total Arthropods	16.04	13.08	5.55	26.66	54.53	55.42
Percentages of Thysanura in total insects	48.96	31.86	14.09	41.46	74.97	65.54
Range from	200	100	0	300	400	1400
Range to	3500	1900	3000	7100	6200	7200

2. Means per acre under various rotational periods

Figure 2 shows the means per acre under various crops or fallows. Means under summer fallows in fields (A) to (C) and (E) were lower than those under the succeeding crops and, in some fields (A and C), the preceeding crops also. This

FIG. 2 : Means per acre under various rotational periods (A to F, fields examined).

was not in parallel with the mean under autumn fallow in field (D) where it was higher than both means of succeeding and preceeding crops. The lowest means were met with during the wheat period in field (B) or during the summer fallow period in field (C). During these two periods irrigation was not carried out. These facts assure the effect of heat and humidity on the thysanuran fauna.

The highest mean in light clay soils was met with under fallow preceeded by cotton in field (D) where it reach 2.500.000 specimens per acre. In clay loam soils the highest mean was under cabbage in field (F) where it reached 4.086.000 specimens per acre.

3. *Fluctuations throughout the year*

The polygons representing thysanuran maginitude in the six fields examined throughout the year are illustrated in Figure 3 which shows that these insects might thrive at any time provided that humidity and temperature are suitable. This interpreted their high levels under cotton in field (D) where there were shade and

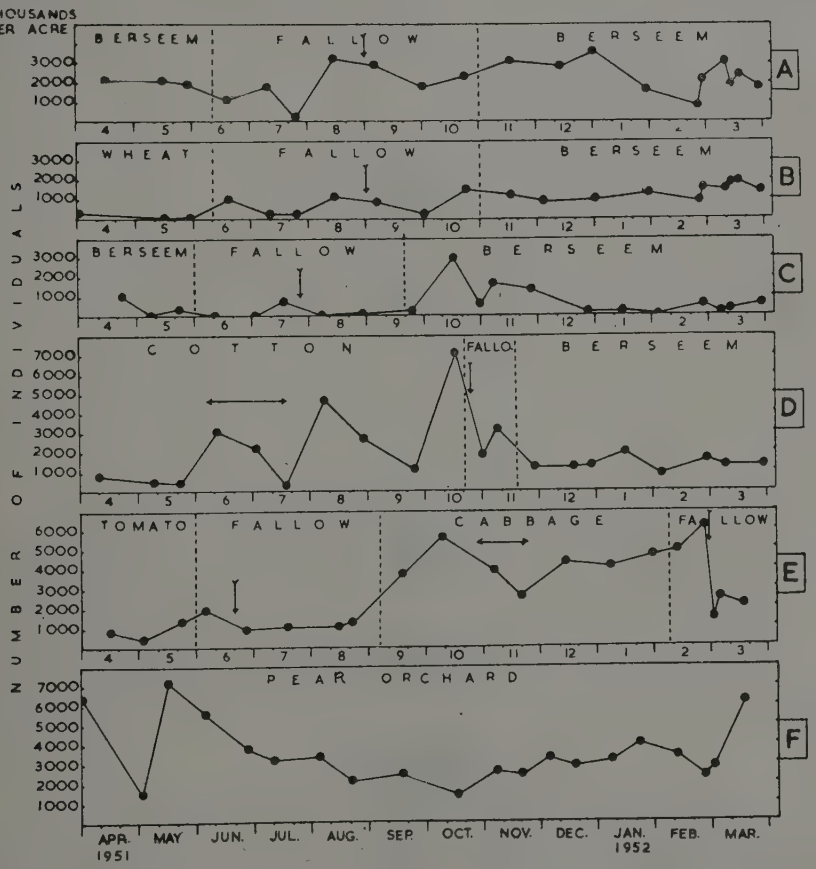

FIG. 3 : Fluctuation of means per acre throughout the year (A to F, fields examined). Vertical arrows refer to dates of ploughing; horizontal arrows refer to periods of dusting.

regular irrigation, their scarcity under wheat in field (B) and under summer fallow in field (C) where the soil remained dry for a long period. The regular irrigation in field (F) together with the proper shade of the pear trees during summer might interpret the comparative stability of thysanuran fauna in this field.

4. Vertical distribution

Figure 4 shows the means per acre per annum for every single inch of every stratum examined. In all fields the upper six inches, representing the layer usually disturbed by ploughing, contained much less thysanurans than the successive nine inches or the undisturbed layer. With the exception of field (F), the stratum between 10 and 15 inches below the soil surface contained alone more insects than all the above strata combined. This also shows the tendency of Thysanura to live in deeper layers, apart from dryness and light.

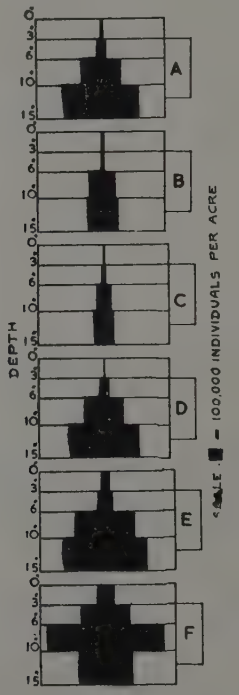

FIG. 4 : Vertical distribution, means per inch (A to F, fields examined).

By sampling down to thirty inches below the soil surface at one occasion in November 1951, it was noticed that Thysanura, especially *Parajapyx*, could penetrate the soil down to that depth in fields (D) and (F). It was observed that thysanurans composed the main insect fauna below the upper fifteen inches. Had sampling been carried out to thirty inches below the soil surface throughout the year, the means per acre would have been greatly increased.

B. Thysanuran components

1. Means per acre per annum

Thysanurans were belonging to only two genera, viz : *Parajapyx* and *Anajapyx*. Table II shows the means per acre per annum for the two genera, and their percentages in total thysanurans. Specimens belonging to the former genus

TABLE II

Means per acre annum in thousands and percentages in total Thysanura of the two thysanuran genera (Parajapyx *and* Anajapyx).

Fields	Means per acre per annum in thousands			Percentages in total Thysanura		
	Parajapyx	*Anajapyx*	Total Thysanura	*Parojapyx*	*Anajapyx*	Total Thysanura
A	2105	10	2115	99.5	0.5	100
B	935	0	935	100.0	0.0	100
C	555	40	595	93.3	6.7	100
D	1895	35	1930	98.2	1.8	100
E	2700	10	2710	99.6	0.4	100
F	3465	35	3500	99.0	1.0	100

exceeds enormously those of the latter one. In light clay soils the highest mean for *Parajapyx* was 2.105.000 specimens per acre in field (A), while this was only 40.000 specimens per acre for *Anajapyx* in field (C). In clay loam soils the highest mean for *Parajapyx* was 3.465.000 specimens per acre in field (F) and 35.000 specimens per acre only for *Anajapyx* in this field. *Anajapyx* was totally absent in field (B). Its percentages in all fields did not exceed 7% of the total Thysanura. Consequently *Parajapyx* composed the main thysanuran fauna in the soil at Giza district.

2. Monthly means per acre

Table III shows the highest monthly means of *Parajapyx* and *Anajapyx* met with at any occasion of the year, together with the crops under which these means were found and the months during which they occurred. It could be noticed that in case of *Anajapyx* all highest means were met with in November while those of *Parajapyx* occurred at various months. The superiority of *Parajapyx* over *Anajapyx* at all occasions was so remarkable that it could be considered that the polygons in Figure 3 could represent to a large extent the faunal fluctuations of the former genus. Figure 2, representing also the means under various rotational periods, could illustrate the approximate means of this genera in this respect. This also would apply to the vertical distribution illustrated by Figure 4.

TABLE III

Highest monthly means per acre for Parajapyx *and* Anajapyx *and the months in which they were met with*

Field	Crops	*Parajapyx*		*Anajapyx*	
		Highest mean	Month	Highest mean	Month
A	Berseem	3500	January	200	November
B	Berseem	1900	March		—
C	Berseem	3000	October	400	November
	Cotton	7100	July		
D	Fallow			500	November
E	Fallow	6200	February		
	Cabbage			200	November
F	Pear trees	7200	May	300	November

C. Factors responsible for thysanuran fluctuations

The fluctuation of thysanuran fauna in the present attempt might be due to several factors working at the same time. The following are only some observations which had been accumulated in the course of the present work.

1. — As mentioned before, Thysanura showed great sensity to temperature and dryness. Lower counts were, consequently, met with under summer fallows or when the soil was dry. Higher counts were usually met with after irrigation.

2. — Thysanuran magnitude was also affected by the soil type. Means were generally higher in clay loam soils than in light clay soils. There was a significant positive correlation between thysanurans and fine sand ($r = + 0.781$) and a significant negative correlation between them and both clay and loss on ignition ($r = - 0.971$ and $- 0.865$, respectively).

3. — The effect of ploughing on thysanurans was very clear. Not only there was a decline in total thysanuran magnitude in all fields after ploughing, but this decline happened also in all strata examined. In Figure 3, the time of ploughing was recorded by vertical arrows. A kind of recovery took place afterwards.

4. — Though thysanurans were affected by dusting (as shown in Figure 3) where the horizontal arrows show the period of dusting, yet recovery took place sooner or later. Dusting was carried out by cotton dust on cotton in field (D) and by gamaxane followed by calcium arsinate on cabbage in field (E). This fauna seemed to migrate deeply in the soil.

IV. SUMMARY

(1) Means per acre per annum of thysanuran fauna and its components were higher in clay loam soils than in light clay soils. Two fields of the former type

and four of the latter were examined. Means and percentages of thysanurans in total insects and in total arthropods were recorded in these fields.

(2) Means under various crops or fallows were estimated.

(3) Fluctuations of thysanuran fauna in these fields throughout a year were illustrated.

(4) The vertical distribution of thysanuran fauna down to 15 inches below the soil surface was explained.

(5) *Parajapyx* and *Anajapyx* were the two main genera met with. The first was actually more prevailing than the second. Means per acre per annum and monthly means were illustrated for the two genera in all fields.

(6) Factors affecting soil Thysanura were briefly discussed.

PART V : MAGNITUDE AND VERTICAL DISTRIBUTION OF DIPTERA

I. INTRODUCTION

The status of dipterous fauna among other arthropods was illustrated by MORRIS (1922), THOMPSON (1924), CAMERON (1925 - 1926) and EDWARDS (1929). According to JACOT (1940), flies affect the soil in oviposition, as a retreat for pupation and as a medium of the immature stages of certain families. Their effect, according to this investigator, varies with the size of the insect, extent of barrow and local abundance of species. He recorded that the diet of the soil dipterous larvae vary greatly, as some live in the decaying organic matter, some eat plant roots (Tipulids and Cecidomyids larvae), some are scavengers (Chironomids and Sciarids larvae), while others are predators on mites or other soft bodied insects (Cecidomyids, Thereviids, Bibionids and Asilids larvae).

Critical soil work, according to STRICKLAND (1944), is required to solve many problems in the elucidation of the life-cycle of the economically important Diptera. KÜHNELT (1955) shows the function of dipterous fauna in the soil.

II. PROCEDURE

Similar to that stated in Part IV.

III. EXPERIMENTAL RESULTS AND DISCUSSION

A. Total diperous fauna

1. Means per acre per annum and percentages

Diptera composed a moderate fraction of the total insect fauna as shown by Figure 5 which illustrates the means per acre per annum and the percentages

of dipterous fauna in total insects. It could be noticed that these means fluctuated from field to field. The highest mean (980.000 specimens) was met with in field (D) while the lowest one (245.000 specimens) was met with in field (E). Ranges per acre

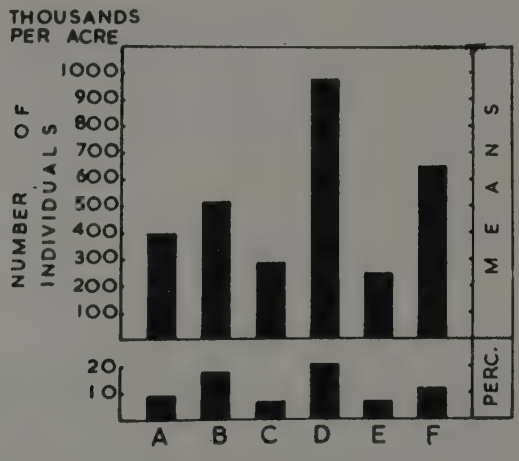

FIG. 5 : Means per acre per annum and percentages, in total insects (A to F, fields examined).

were from nil to 1.400.000 specimens in field (A), from nil to 2.300.000 specimens in field (B), from nil to 1.000.000 specimens in field (C), from nil to 7.500.000 specimens in field (D), from nil to 700.000 specimens in field (E), and from nil to 4.600.000 specimens in field (F).

Percentage of dipterous fauna in total insects ranged from about 2 to 21% in light clay soils (fields A to D) and from about 7 to 12% in clay loam soils (fields E. and F). These percentages in total Arthropoda, ranged from 3 to about 14% in the former soil type and from about 5 to 10% in the latter soil type.

2. Means per acre under different rotational periods

Figure 6 illustrates the means of dipterous fauna under different crops or fallows. These means fluctuated greatly, not only under different crops or fallows, but also under the same crop from field to field. The highest mean met with (2.100.000 specimens) was under berseem preceeded by cotton in field (D). With the exception of the spring fallow in field (E), the means per acre under other fallows were lower thae thosn under the preceeding or succeeding crops.

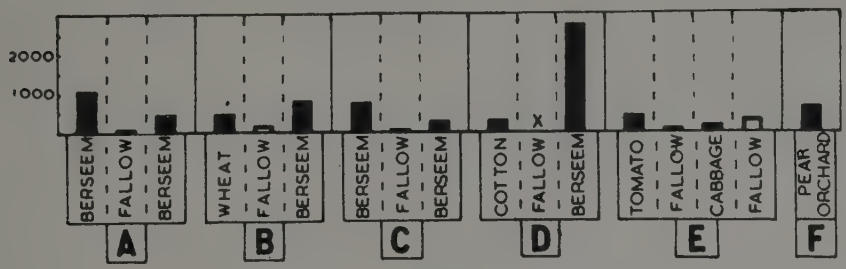

FIG. 6: Means per acre under various rotational periods (A to F, fields examined).

3. *Vertical distribution*

Figure 7 shows the vertical distribution of dipterous fauna among the four strata (from the soil surface down to fifteen inches below).

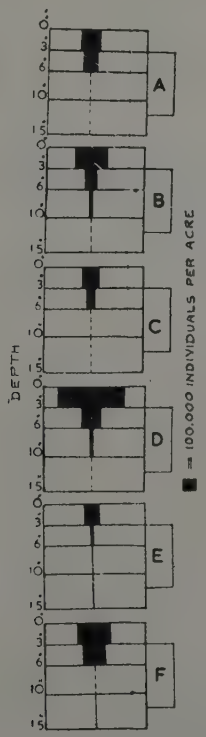

FIG. 7 : Vertical distribution, means per inch (A to F, fields examined).

The number of Diptera generally decreased with the increase in depth. The number of specimens existing in the three inch surface layer exceeded the number existing in the three-inch successive layer. These two layers, or the layer usually disturbed by ploughing (from surface of the soil down to six inches below) contained the largest fraction of the dipterous fauna.

4. Fluctuation of dipterous fauna throughout the year

Figure 8 shows the total means throughout the year in all fields examined. It could be noticed that the number of Diptera decreased greatly in late summer and early autumn. This was clear, particularly under summer fallows. In field (F), under pear orchard, though the shade of the green trees during summer may regulate the soil temperature, yet the dipterous fauna was absent in samples obtained during the period July-August. High levels or peaks were generally noticed in late November and in December. The remarkable increase of dipterous fauna in field (D) during the latter month and in January under berseem preceeded by cotton was very-noticeable.

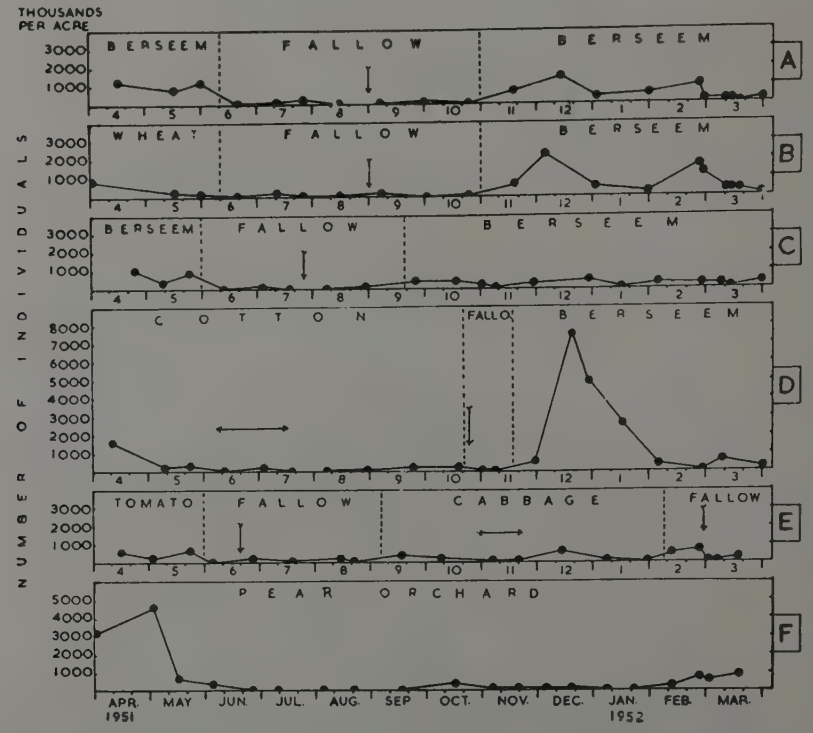

FIG. 8 : Fluctuation of means throughout the year (A to F, fields examined). Vertical arrows refer to dates of ploughing; horizontal rows refer to period of dusting.

B. Dipterous stages

1. Means per acre per annum

These means are shown by Figure 9. Dipterous pupae composed a considerable fraction of dipterous fauna. In four fields (B to E) they were more in number than larvae and adults combined. Their percentage in field (D) reached

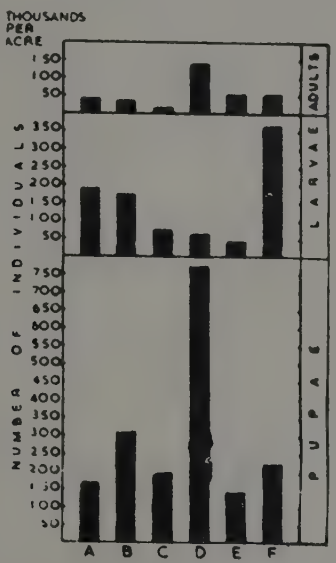

FIG. 9 : Means per acre per annum of dipterous stages (A to F, fields examined).

79.08% of the dipterous fauna. The larvae ranked first in field (A) and (F) but second in fields (B), (C) and (E). Adult percentage only exceeded that of larvae in field (D).

The highest mean was 140.000 adults in field (D), 365.000 larvae in field (F) and 775.000 pupae in field (B).

2. Means per acre under various rotational periods

Table IV shows the means per acre of dipterous stages under various rotational periods. The pupal means under fallows were in most cases lower than those under the preceeding or succeeding crops. Either the adults or the larvae or both were absent under fallows with the exception of the spring fallow in field (E) where all stages were present while absent under the fallow in field (D). The pupal means under crops (with some exceptions as those under berseem during the period April-June in fields (A and C) exceeded the adult or larval means, especially under berseem during autumn and winter in fields (A) to (D).

TABLE IV

Means per acre in thousands of dipterous stages under various rotational periods

Fields	Rotation	Stages			Total
		Adults	Larvae	Pupae	
A	Berseem	33	967	67	1067
	Fallow	0	0	57	57
	Berseem	70	90	270	430
B	Wheat	33	100	334	467
	Fallow	14	0	115	129
	Berseem	50	230	440	810
C	Berseem	33	400	300	733
	Fallow	0	0	40	40
	Berseem	17	25	233	275
D	Cotton	30	90	160	280
	Fallow	0	0	0	0
	Berseem	312	50	1738	2100
E	Tomato	133	0	300	433
	Fallow	20	0	80	100
	Cabbage	29	57	114	200
	Fallow	80	100	160	345
F	Pear orchard	55	365	225	645

3. Monthly and annual means of certain dipterous stages

Table V shows the highest monthly mean of any dipterous stage met with and the month during which it was noticed. December stood first in rank in this respect. With the exception of field (F) the pupae in all other fields reached their highest counts during this month. Larvae reached their maxima in April in fields (A), (C), (D) and (F). Adults flourished at various months. Generally speaking, dipterous stages flourish in seasons other than summer.

Both Anisopidae and Mycetophilidae composed the largest fraction of the soil dipterous fauna. The first family was represented entirely by larvae while the second, by adults and pupae. Table VI shows the Anisopid larval means per acre per annum and their relative abundance. These larvae formed the total larval dipterous fauna in three fields (A, B and F) while they made up from about 73 to 92% of this fauna in other fields. Table VII illustrates the monthly means of the Anisopid larvae. They flourished mainly during seasons other than summer (especially in April).

TABLE V

Monthly highest means of dipterous stages and months when they were met with in fields examined

Fields	Stages	Highest monthly mean per acre	Month of highest mean
A	Adults	200	November
	Larvae	1100	April
	Pupae	1200	December
	All stages	1400	December
B	Adults	200	December
	Larvae	900	December
	Pupae	1200	December
	All stages	2300	December
C	Adults	50	May, October, February
	Larvae	700	April
	Pupae	500	December
	All stages	1000	April
D	Adults	800	December
	Larvae	400	April
	Pupae	5300	December
	All stages	6200	December
E	Adults	300	April
	Larvae	200	September, February
	Pupae	500	December
	All stages	600	December, February
F	Adults	150	December
	Larvae	2100	April
	Pupae	1100	April
	All stages	3200	April

Table VI also shows the Mycetophilid adult means per acre per annum and their relative abundance while Table VIII shows their montly means per acre. Mycetophilid adults, with the exception of the case in field (E), composed a considerable fraction of the adult dipterous fauna. Their abundance during winter was noticeable.

Table VI shows also the mycetophilid pupal means per acre per annum and their relative abundance while Table IX shows their monthly means per acre. Mycetophilid pupae formed a more or less large fraction of the dipterous pupae, reaching in field (D) about 83% of this fauna. Their absence during the period June-August was remarkable. They existed mainly during December and January.

It is worthy mentioned that field (C), with long and dry summer fallow, was the poorest in its mycetophilid fauna.

TABLE VI

Means per acre per annum in thousands of Anisopid larvae, Mycetophilid adults and pupae.

Dipterous fauna	Fields					
	A	B	C	D	E	F
Anisopidae						
1. Means per acre per annum (in thousands)						
Anisopid lavae	190	175	55	60	40	365
Other dipterous larvae	0	0	20	5	5	0
Total dipterous larvae	190	175	75	65	45	365
2. Percentages (in total dipterous larvae)						
Anisopid larvae	100	100	73.33	92.31	88.89	100
Other dipterous larvae	0	0	26.67	7.69	11.11	0
Total dipterous larvae	100	100	100	100	100	100
Mycetophilidae (Larvae)						
1. Means per acre per annum (in thousands)						
Mycetophilid adults	35	25	10	95	5	30
Other dipterous adults	5	10	5	45	50	25
Total dipterous adults	40	35	15	140	55	55
2. Percentages (in total dipterous adults)						
Mycetophilid adults	87.50	72.43	66.67	67.86	9.09	54.55
Other dipterous adults	12.50	28.57	33.33	32.14	90.91	45.45
Total dipterous adults	100	100	100	100	100	100
Mycetophilidae (Pupae)						
1. Means per acre per annum (in thousands)						
Mycetophilid pupae	75	80	25	640	10	75
Other dipterous pupae	90	230	170	135	135	150
Total dipterous pupae	165	310	195	775	145	225
2. Percentages (in total dipterous pupae)						
Mycetophilid pupae	45.45	25.81	12.82	82.80	6.90	33.33
Other dipterous pupae	54.55	74.19	87.18	17.20	93.10	66.67
Total dipterous pupae	100	100	100	100	100	100

TABLE VII

Monthly m ans per acre of Anisopid larvae (in thousands)

	Months	Fields					
		A	B	C	D	E	F
1951	April	1100	100	700	400	0	2100
	May	900	100	50	200	0	2100
	June	0	0	0	0	0	0
	July	0	0	0	0	0	0
	August	0	0	0	0	0	0
	September	0	0	100	0	200	0
	October	0	50	50	0	100	100
	November	400	500	0	60	50	0
	December	100	900	0	100	0	0
1952	January	0	0	0	0	0	0
	February	150	850	0	0	100	0
	March	25	25	33	0	33	450

TABLE VIII

Monthly means per acre of Mycetophilid adults in thousands

	Months	Fields					
		A	B	C	D	E	F
1952	April	0	0	0	0	0	0
	May	50	0	50	0	0	0
	June	0	0	0	0	0	50
	July	0	0	0	0	0	0
	August	0	0	0	0	0	0
	September	0	0	0	0	0	0
	October	0	0	0	0	0	0
	November	200	200	0	100	-	0
	December	100	100	0	700	100	50
1951	January	150	50	0	150	0	50
	February	0	0	50	0	0	50
	March	0	0	0	0	0	100

TABLE IX

Monthly means per acre of Mycetophilid pupae in thousands

	Months	Fields					
		A	B	C	D	E	F
1952	April	0	0	0	400	0	900
	May	0	0	0	0	0	300
	June	0	0	0	0	0	0
	July	0	0	0	0	0	0
	August	0	0	0	0	0	0
	September	0	0	0	0	0	0
	October	0	0	5	0	0	0
	November	0	0	5	0	0	0
	December	800	450	0	2100	100	0
1951	January	250	150	0	2200	0	0
	February	100	0	0	0	0	0
	March	0	100	0	0	33	0

C. Identification of dipterous fauna met with (1951-1952)

The following formulae, after MORRIS (1922) and EDWARDS (1929) summarise most of the facts previously mentioned. In each formula, the capital letters denote the fields (A, B, etc.). The arabic figures outside the brackets denote the months during which the specimens mentioned were met with. The first arabic figure within the brackets denotes, above, the total number of individuals obtained in all fields (in 600 samples) and, below, in Roman numerals, the strata in which they existed. The second arabic figure within the brackets denotes, above, the maximum number met with at any one level in any field (for five bulked samples) and, below, in Roman numerals, the stratum or strata where this number was found.

(1) MYCETOPHILIDAE : A. Adults (all fields; 1 to 3, 5, 6, 11, 12 ($\frac{40}{I,II,IV}$; $\frac{8}{1}$);

B. Pupae (all fields; 1 to 5, 9 to 12 ($\frac{181}{I, II, III}$; $\frac{5\text{-}2}{\quad}$).

(2) CHIRONOMIDAE : B, E, F; 4 to 6, 10, 12 ($\frac{8}{1, II, IV}$; $\frac{2}{IV}$).

(3) Bibionidae : C, D, E; 2, 10, 12 ($\frac{7}{\text{I, II, IV}}$; $\frac{2}{2}$).

(4) Culicidae : B ; 10 ($\frac{1}{\text{IV}}$) ?

(5) Sepsidae (*Lispa* sp.) : E ; 2 ($\frac{1}{1}$).

(6) Borboridae : E ; 2 ($\frac{1}{\text{I}}$).

(7) Anisopidae (larvae only) : all fields; 2 to 5, 7, to 12 ($\frac{177}{\text{I, II, III}}$; $\frac{31}{\text{II}}$).

(8) Therevidae (larvae) : E; 2 ($\frac{1}{1}$).

(9) Other Diptera : A. Adults A, D, E, F, 1 to 6, 9, 11 ($\frac{10}{\text{I, II, III, IV}}$);

B. Larvae C, D; 1, 5 ($\frac{5}{\text{I, II, IV}}$);

C. Pupae (Coarctate), all fields, all months ($\frac{182}{\text{I, II, III, IV}}$).

Within 600 random samples of the four inch core, obtained from the six fields examined, 614 dipterous specimens were extracted. Of this number, 68 (11.07%) were adults, 183 (29-80%) were larvae and 303 (59.12%) were pupae.

IV. SUMMARY

(1) Six fields of two soil types were examined. Means per acre per annum, means under various rotational periods and monthly means were recorded for total dipterous fauna and for dipterous stages.

(2) Vertical distribution down to fifteen inches below the soil surface was illustrated. The upper six inch layer contained most of the dipterous fauna.

(3) The fluctuations of means throughout a year and fluctuations in vertical distribution of the fauna during this period were discussed.

(4) Identification of the fauna extracted was referred to.

PART VI: MAGNITUDE AND VERTICAL DISTRIBUTION OF COLLEMBOLA

I. INTRODUCTION

Springtails are found by enormous numbers in the soil as recorded by BUCKLE (1921), MORRIS (1920, 1922 and 1927), THOMPSON (1924), CAMERON (1925-26) and EDWARDS (1929). They form, according to WILLIAMS (1942), the base of the soil animal food chain. They can occur, according to STRICKLAND (1944), in all types of soil and under all types of vegetative covering.

JACOT (1940) records that springtails abound in all moist and fairly moist soils to unknown depths, being more abundant in the upper layers and in the litter. They are common throughout the year. Though not fitted for digging, JACOT (1936) refers to their undoubted importance in keeping open the channels formed by mites. He states that most of the soil species are eyeless and unpigmented.

II. PROCEDURE

As stated in Part IV.

III. RESULTS AND DISCUSSION

1. Means per acre per annum

Figure 10 shows the means per acre per annum of the springtails extracted throughout the year and their percentages in total insects. The highest mean met with was in field (C) where the mean was 2.105.000 specimens per acre per annum. Springtails in this field composed about half the total insect fauna (49.88%) or 19.63% of the total Arthropods. Means in other fields were much lower, ranging from 75.000 to 285.000 specimens per acre per annum. In these fields, springtails composed a small fraction of the total insect fauna or the total arthropods. They composed from 2.07 to 5.79% of the former and from 1.40 to 4.51% of the latter fauna.

Fluctuations of means were conspicuous. The widest range was from nil to 6.700.000 specimens per acre in field (C) and the narrowest range was from nil to 300.000 specimens per acre in field (E).

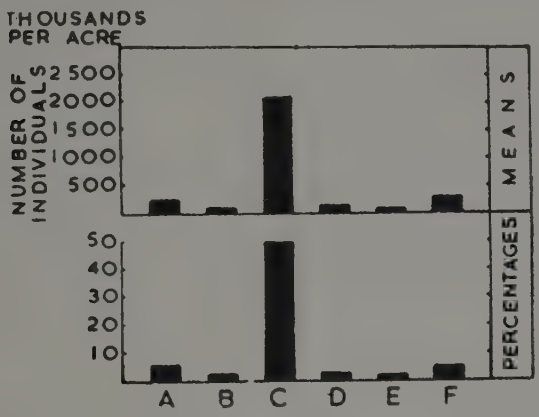

FIG. 10 : Means per acre per annum and percentages, in total insects (A to F, fields examined).

2. Means per acre under various rotational periods

Figure 11 illustrates the magnitude of springtails under various crops and fallows. Though the soil under the fallow in field (C) was very dry and the time was summer, yet the magnitude of springtails under it was nearly similar to their number under the preceeding or the succeeding crop (berseem). This stability in such wide

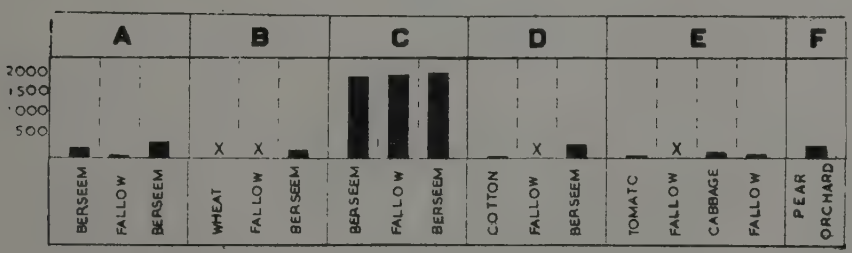

FIG. 11 : Means per acre under various rotational periods (A to F, fields examined).

circumstances may be due to the tendency of the springtails existing in this field to be abundant in lower strata as will be shown later on. Means per acre under various rotational periods in this field were comparatively high; more thae two millions per acre for every period.

In fields other than field (C), the means were conspicuously low. Under fallows of these fields, the fauna was either absent or actually lower than the preceeding or succeeding crops. Springtails were also absent under ripen wheat in field (B). This shows the effect of green covering on the degree of abundance of these

insects. With the exception of the case in field (C), the highest mean in other fields was 285.000 specimens per acre under pear orchard (field F) and 280.000 specimens under berseem in field (A). The lowest crop mean was 20.000 specimens per acre under cotton.

3. Vertical distribution

Springtails penetrated the soil downwards to at least fifteen inches below the soil furface, as shown by Figure 12 which shows these means per single inch in strata examined. Field (C) was also exceptional as the springtails, existing in it, increased with the increase of depth. The reverse happened in other fields. In these latter

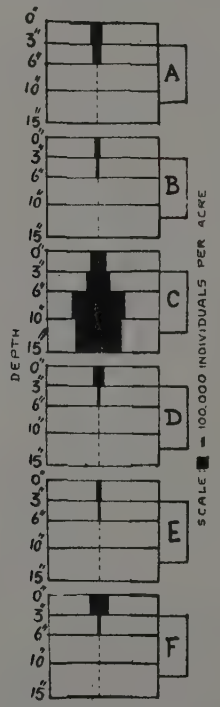

FIG. 12 : Vertical distribution (A to F, fields examined).

fields the three-inch surface layer contained more than the total number existing in other layers combined. There was a tendency of Collembola to decrease with the increase of depth, as the successive three-inch layer (between 3 and 6 inches) also contained a more considerable fraction of the fauna in most cases, than existing

in the nine-inch successive layer (between 6 and 15 inches). In other words the disturbed six-inch surface layer in all fields other than field (C) contained most of the collembolan fauna.

In field (C) the highest mean per acre per inch in depth was 205.000 specimens in the layer between 6 and 10 inches. In other fields the highest mean per acre per inch of the soil was 66.667 specimens in field (F) in the three-inch surface layer.

4. Fluctuation of fauna throughout the year

In Figure 13, the polygons show the fluctuations of total Collembola in each field throughout the year. In field (C), springtails were found to exist at all occasions of the year (except in June) in fluctuated numbers. The absence of the insects in the

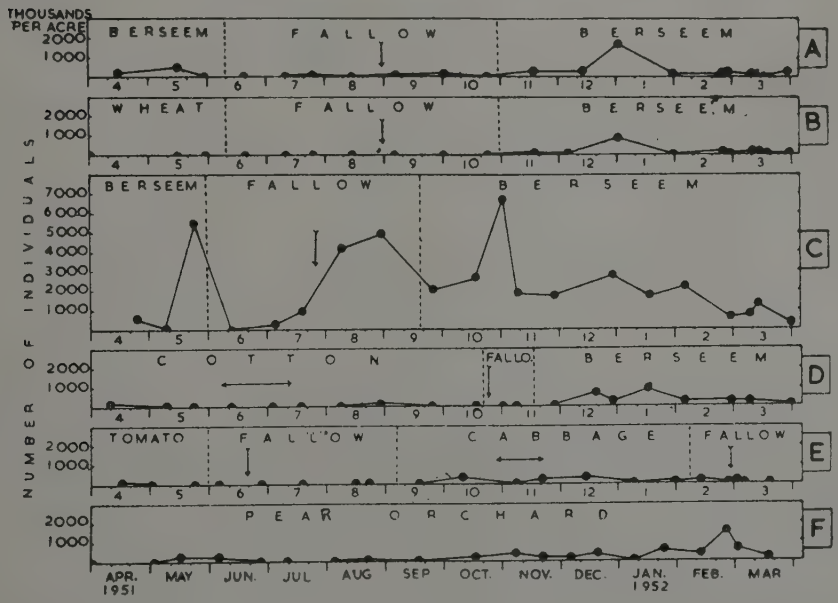

FIG. 13 : Fluctuation of means per acre throughout the year (A to F, fields examined). Vertical arrows refer to dates of ploughing; horizontal arrows refer to periods of dusting.

three-inch surface layer under the fallow of this field was noticed. The increase of them with the increasing depth in most cases during the year was also remarkable. Nevertheless, the comparative migration of the springtails towards the top layer under berseem from September to March was worthy of notice. This might be due to the green covering at that period.

In fields other than field (C,), many remarks could be noticed. While the migration of the insects towards the deeper strata occured under the fallow in field (A), the reverse happened when there was a green covering (berseem). In field (B) the insects were absent under wheat or fallow (dry soil) while they existed only under berseem. The relative abundance of the insects under green covering was also noticed under berseem in field (D) and under cabbage in field (E).

Table X shows the highest means per acre and the month during which these means were met with. It could be noticed that these means took place under green crops in general and during autumn and winter.

TABLE X

The highest means per acre in thousands and the months during which they appeared

Field	Highest mean	Crop	Months
A	1700	Berseem	January
B	900	Berseem	January
C	6700	Berseem	October
D	900	Berseem	January
E	300	Chabbage	October, November
F	1700	Pear trees	February

5. *Identification of fauna*

The springtails extracted belonged to the suborder Arthropleona. Both *Poduromorpha* sp. and *Entomobryomorpha* sp. were represented. All samples found were pigmented, with the exception of the dominating species in field (C) which was unpigmented (white). This species was comparable to the white one described by JACOT (1936) as being able to burrow into the soil, hence its exceptional abundance and vertical distribution. This exceptional abundance of this species in field (C) may be interpreted according to the work of BAWEJA (1939) who stated that in sterilized soils, some insects as Collembola could thrive while others could not maintain themselves. Circumstances in field (C) could allow it to reach partial sterilization (temperature may reach 68 C° at soil surface as recorded by TAYLOR and BURNS (1924) and shown by SUTTON 1946 in Giza district). The phenomenon of BAWEJA could apply correctly to the case of collembolan fauna in this field.

From 600 samples obtained from the six fields 594 springtails were extracted. The maximum number per similar five bulked strata obtained at any time was 15 individuals in the stratum between 6 inch and 10 inch in field (C).

IV. SUMMARY

(1) Means per acre per annum and means under rotational periods were given in six fields four of which were light clay and two were clay loam. The fluctuations of these means throughout the year were illustrated.

(2) The vertical migration was also discussed.

(3) One field (C) was exceptional as to magnitude of fauna, vertical distribution of it and the kind of fauna existing. The remaining five fields were nearly similar. Reasons for this variation were given.

PART VII : MAGNITUDE AND VERTICAL DISTRIBUTION OF OTHER INSECT ORDERS

I. INTRODUCTION

In previous papers the writer (1957) showed the fluctuations of the total Arthropods, the magnitude and vertical distribution of the main insect orders in the soil of the farm of the Faculty of Agriculture at Giza. During the course of the work, several insect specimens belonging to other orders were extracted and will be discussed in the present part. Concerning orders treated here two main facts should be born in mind :

(1) The number of insects belonging to the various orders recorded later on was more or less scarse. Consequently, their magnitude, as illustrated in this part, gives a mere conception about their status in the cultivated soil in Giza district. To give more precise and accurate estimation, the number of the sampling units should be greatly increased. This applies more correctly to Orthoptera, Neuroptera ,and Psocoptera.

(2) These orders include true soil insects (geoxenes as denoted by JACOT, 1940), secondary soil insects (geophiles) and other insects which are found accidently in the soil (strays).

II. PROCEDURE

Six fields, denoted (A) to (F) were selected for faunal examination. Four of them (A to D) were light clay and the other two (E and F) were clay loam. One hundred random samples were obtained from each field during a period of a year beginning in April 1951 and ending in March 1952. Each sample was four inches in diameter and was taken off to fifteen inches below the soil surface. The sample

was divided into four strata, viz. 0-3", 3-6", 6-10" and 10-15". The fauna was extracted by the flotation method.

NOTA BENE : The method of obtaining the samples, way of dividing it into four strata, procedure of extracting the fauna, the mechanical analyses of fields examined, their botanical censuses and the meteorological conditions of the district were all discussed in details by the writer (1957).

III. RESULTS AND DISCUSSION

1. Hymenoptera

Many hymenopterous insects belonging to various families burrow into the soil either to pupate or to build nests. Ants, existing in the soil by huge numbers, are considered very important as scavengers and predators. Other hymenopterous fauna may burrow about through the soil in search of their host (JACOT, 1940).

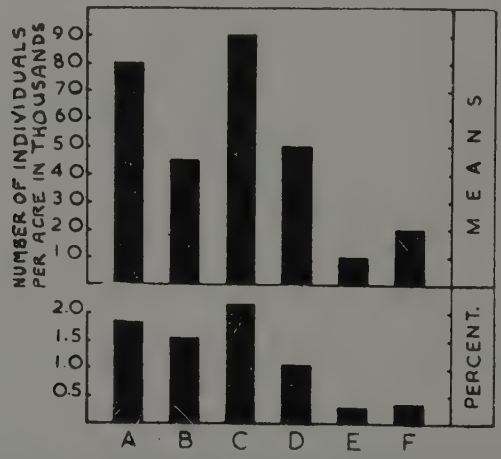

FIG. 14 : Means per acre per annum and percentages, in total insects of the hymenopterous fauna (A, B, C, and D, light clay soils; E and F, clay loam soils).

But most investigators do not include ants with other Hymenoptera, because they are social insects and their estimation by the usual method is misleading (EDWARDS, 1929). TALBOT (1934 and 1943) discusses various aspects about these insects. In the present experiment, though numerous specimens of ants were present in some samples, nothing was found in many others. In the present work ants were not included and all the numbers given hereafter represent hymenopterous fauna other than ants.

Hymenopterous insects were not so numerous as compared by other insect fauna. Their means per acre per annum and their percentages in total insects are shown in Figure 14. Though these means fluctuated from field to field, yet they were in general lower in clay loam soils (fields E and F) than in hight clay soils (fields A to D). The highest mean in former soil type was 20.000 specimens per acre per annum while it was 90.000 specimens in the latter soil type. Hymenoptera composed a small fraction of the total insect fauna; their percentages did not exceed much over 2% but might dropp to less than 0.3%.

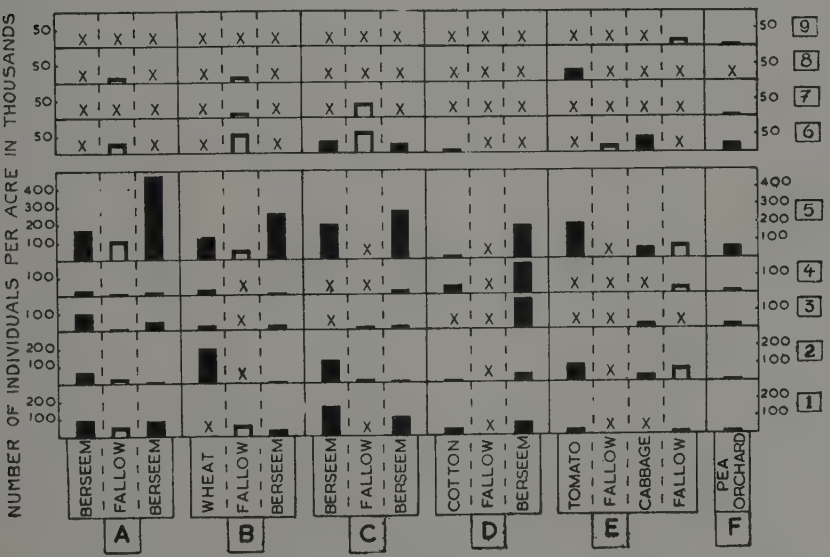

FIG. 15 : Means per acre under various rotational periods (A to F, fields examined; 1, Hymenoptera; 2, Thysanoptera; 3, Macrolepidoptera; 4, Hemiptera; 5, Homoptera; 6, Orthoptera; 7, Neuroptera; 8, Microlepidoptera; 9, Psocoptera).

Figure 15:1 shows the means per acre under various rotational periods. The highest means (166.667 specimens) was found under berseem in field (C). In most cases the means under fallow were lower than the preceeding or succeeding crops.

With minor exceptions, the six-inch surface layer contained more hymenopterous insects than the nine-inch layer beneath. These insects could penetrate the soil down to at least fifteen inches below the soil surface. In some fields their penetration did not exceed the upper six-inch layer.

In general, Hymenoptera were scarse throughout the year, being present only during April 1951, June, December and January 1952, and March in field (A)

where the highest monthly mean was 400.000 specimens during June under fallow. They were met with during June, September, October December, January and February in field (B) where the highest monthly mean was 300.000 specimens during October under berseem. In field (C), they were found during April, May, October, November, February and March; the highest mean was 600.000 specimens during November under berseem. In field (D), they were met with during May, August, September and February and the highest monthly mean was 300.000 specimens during February under berseem. In clay loam soils the insects were only met with during May and March in field (E) and during February, January and March in field (F). In field (F) the mean per month was 100.000 specimens while the highest monthly mean in field (F) was 200.000 specimens during February under pear orchard.

Various stages of hymenopterous insects were met with in the fields examined. The adults, as shown in Figure 16 were comparatively more prevailing, constituting

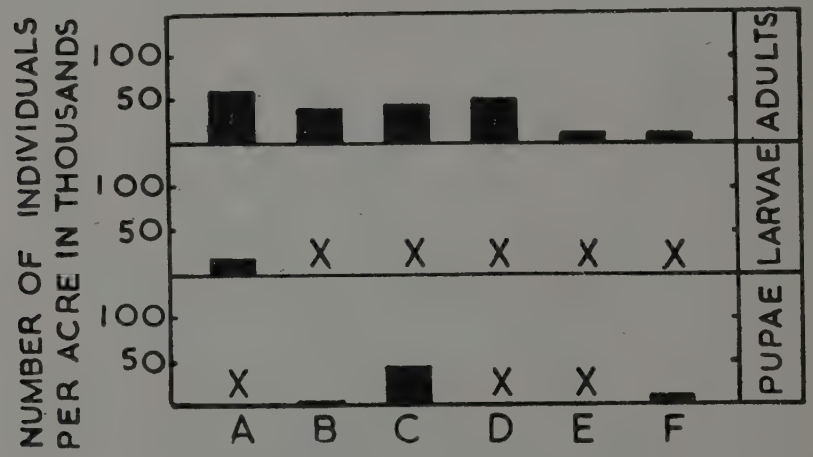

FIG. 16 : Means per annum of hymenopterous stages (A to F, fields examined; A to D, light clay soils; E and F, clay loam soils; X, absence of fauna).

in some cases the total hymenopterous fauna (fields D and E) and in others 50% or more of this fauna.

The scarcity of *Hymenoptera* in the soil may be due to the following factors :

(*a*) As stated before, adult Hymenoptera formed the larger fraction of the soil hymenopterous fauna. These are found in the soil crevices. They could possibly take to wing when feeling any disturbance either when hammering the cylinder during sampling or during emptying it. Hence, secured samples, as shown by JACOT (1936) may be better for estimating hymenopterous fauna.

(*b*) Other hymenopterous stages may be aggregated due to parasitism on other insect stages and, thus, are not uniformly distributed in the soil. This may interpret the absence of these stages in most fields examined.

Due to these factors, and in the writers point of view, the estimation of hymenopterous fauna as presently carried out did not represent the correct status of this fauna as far as the quantitative conception is concerned. Nevertheless, the presentation of the elements of this fauna is very important as to reveal most of the functions of this fauna in the soil. The species extracted were belonging to the families recorded hereafter, together with the formulae (*vide* page 18) which summarize most of the previous facts:

(1) BRACONIDAE (subfamily *Dacnusinae*) : A, C, D, E; 4, 5, 2 (9/1, II, III; 2/I, II).

(2) CYNIPIDAE : A to D; 1, 2 (7/I, II, III; 2/I, II).

(3) CHALCIDIDAE : C, D; 8, 10; (3/II; 2/II).

(4) CERAPHRONIDAE : (a) *Ceraphron* sp., D, E; 2, 3 (3/1, IV; ƺI/). — (b) *Conostigmus* sp., A, B; 1 (4/1, IV; 2/1).

(5) DIAPRIIDAE : (a) *Trichopria aegyptiaca* Priesner, B, C; 10, 12 (2/II). — (b) *Loxotropa* sp., F; 2 (2/1).

(6) APIDAE : *Halictus* sp., B; 6 (I/1).

(7) SCELIONIDAE : (a) *Aegyptoscelio frequens*, A to D; 6, 9, 10, 12 (II/1, II, IV; 4/IV). — (b) *Doddiella similis* Priesner, C; II (I/IV).

(8) Other HYMENOPTERA : (a) Pupae (*Doddiella* sp. and *Aegyptoscelio* sp.), A, C, F; 11, 1, 2, 3 (12/I, II, IV; 6/1). — (b) Larvae, A; 3 (4/1).

Of 59 specimens met with in all fields, 43 of them (72.88%) were adults, 12 (20.34%) were pupae and 4 (6.78%) were larvae.

2. Thysanoptera

Though largely considered as plant feeders, some species of Thysanura, as stated by STRICKLAND (1944), live in the soil and are fungivorous or predaceous, sucking the body fluids of young mites.

Means per acre per annum and percentages in total insects of thysanopterous fauna are shown in Figure 17. The highest mean was 50.000 specimens. met with in field (E). The effect of soil type on thysanopterous magnitude was not noticeable. Thysanoptera composed a small fraction of the total insect fauna as its percentages did not exceed 1.4%.

Means per acre under various rotational periods are shown in Figure 15:2. Though fluctuated more or less from period to period, the highest mean (200.000 specimens) was met with under wheat in field (B) where the soil was dry at that time.

Means under berseem during late spring and early summer were higher than under this crop during autumn and winter.

The disturbed six-inch surface layer contained in most cases more thrips than the undisturbed nine-inch successive layer. Thrips could penetrate the soil downwards to fifteen inches below the soil surface as happened in some fields. Their penetration in other fields did not exceed the upper six or ten inches. It seemed that this penetration had something to do with the number of crevices in the soil.

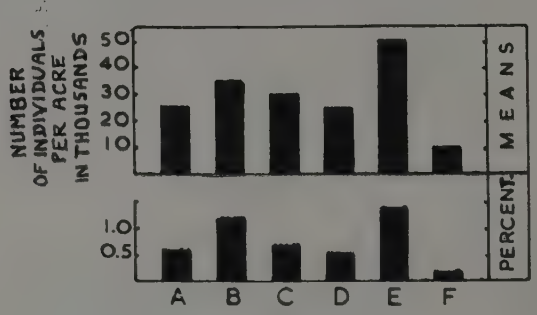

FIG. 17 : Means per acre per annum and percentages, in total insects of the thysanopterous fauna (A to F, fields examined; A to D, light clay soils; E and F, clay loam soils).

Thrips were in general very scarse in all fields examined throughout the year. They were met with during May, July, August and January in field (A) where the highest monthly mean was 200.000 specimens per acre during May under berseem. They were met with during April, May and December in field (B) where the highest monthly mean was 500.000 specimens during May under wheat. Thrips were found during April, June and November in field (C) where the highest mean was 400.000 specimens during April under berseem. They were found during May, January, February and March in field (D) where the highest mean was 200.000 specimens in February under this crop. April, September, December, February and March were the months during which the fauna appeared in field (E) where the highest monthly mean was 300.000 specimen during April under tomato. Thrips were only met with during October and November in field (F) where the highest monthly mean was 100.000 during October under pear trees.

The species of thysanopterous fauna are recorded hereafter, together with the formulae which summarize most of the previous facts :

(1) *Aelothrips* spp. : (a) Adults, C, D; 4, 5, 2 (5/I, II; 2/1). — (b) Larvae, A to E, 4 to 9, 12 (17/1, II, III, IV; 2/1, II, IV).

(2) *Thrips tabaci* Lind. : (a) Adults, E; II, 2, 3 (4/1; 2/1). — (b) Larvae, C; 7 (1/1).

(3) *Limothrips cerealium* Haliday, A, B, D; 4, I (4/1, II).
(4) *Frankliniella dampfi*, E, F; 9, 10 (3/I, II).
(5) *Anaphothrips* sp., F, 11 (I/1).

Within 600 random samples obtained from the six fields, 35 specimens of thrips were met with. Of this number 18 (51.43%) specimens were larvae and 17 (48.57%) were adults.

3. Lepidoptera

Many species of lepidopterous insects spend part of their life-cycle in the soil and some cause serious damage to plants. The prevailing soil stages are the pupae and larvae. Much useful soil survey work should be done, according to STRICKLAND (1944), particularly with such relatively large and easy-to-extract insect larvae. This investigator stresses the possibility of foretelling pest years in time to apply control methods, saving much money and trouble.

When at times any of lepidopterous species cause serious defoliation of trees or crops, the individuals that enter the soil would considerably, according to JACOT (1940), exert an effect on soil structure. The comparatively larger larvae, when occurring in suitable numbers, have an important effect in soil channelling.

In Egypt, serious lepidopterous pests of cotton, berseem, maize, etc., viz. the cotton leafworm (*Prodenia litura* F.), the lesser cotton leafworm (*Laphygma exigua* Hb.), and the greazy cutworm (*Agrotis ypsilon* Rott.), etc., pupate in the soil and a considerable number of their larvae use the soil as a retreat or concealment. Their magnitude in the soil could be easily studied by sampling especially during pest seasons and some measures of control may possibly be devised through population studies.

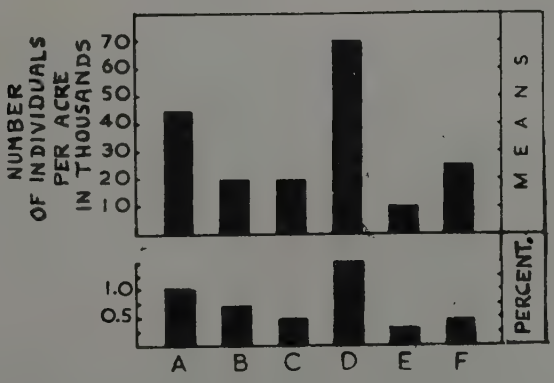

FIG. 18 : Means per acre per annum and percentages, in total insects of the Macrolepidoptera (A to F, fields examined; A to D, light clay soils; E and F, clay loam soils).

In the present experiment, the means per acre per annum, shown in Figure 18, were comparatively low. The highest mean was 70.000 specimens in field (D). Macrolepidopterous percentages did not exceed 1.5% of the total insect fauna.

Means per acre under various rotational periods are shown in Figure 15:3. The insects were absent or scarse under fallows and some crops. The highest mean (175.000 specimens) and the widest range (0-600.000 specimens) were met with under berseem preceeded by cotton.

The six-inch surface layer contained most of the macrolepidopterous fauna. The penetration of insects into the soil did not exceed the ten surface inches and in three fields the whole fauna was found only in the three-inch surface layer.

Though the monthly means were comparatively low, they somewhat increased under berseem. The fauna was met with during April, May and the period October-March in field (A) where the highest mean was 200.000 specimens during April under berseem. The fauna was found during April, December and February in field (B) where the highest mean (200.000 specimens) was met with during February under berseem. The insects were found during July, October, November and March at a rate of 100.000 specimens per month in field (C). They were met with during December, January and March in field (D) where the highest monthly mean was 600.000 specimens in January under berseem. October was only the month during which the insects were found in field (E), at a rate of 200.000 specimens under cabbage. They occurred during May, December, January and February in field (F) where the highest mean was 200.000 specimens during may under pear trees.

Macrolepidopterous fauna extracted was composed only of larvae and pupae; the former formes composed the whole fauna in some of the fields examined.

During the course of the work specimens representing adult microlepidopterous insects were extracted from the samples obtained from fields (A), (B) and

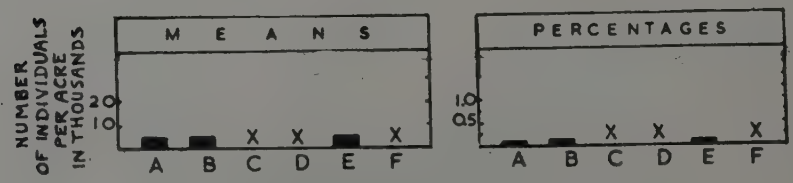

FIG. 19 : Means per acre per annum and percentages, in total insects of the Microlepidoptera (A to F, fields examined; A to D, light clay soils; E and F, clay loam soils; X, absence of fauna).

(E) at a rate of 5.000 specimens per acre per annum, as shown in Figure 19. The percentages of this fauna in total insects were 0.12, 0.17 and 0.14% in the three fields respectively. Microlepidopterous fauna under various rotational periods is shown in Figure 15: 8. In the first two fields the fauna was met with during July

under fallow at a rate of 100.000 specimens for each field during this month. The fauna was met with during April at the same rate in field (E).

Specimens of both Macrolepidoptera and Microlepidoptera extracted were not hitherto identified.

4. Homoptera

Members of this order are relatively scarse in the soil as most of the species are plant feeders both during the nymphal and the adult stages. Aphids are more prevailing, attacking the root systems of certain plants and are often carried, as stated by JACOT (1940) and STRICKLAND (1944), to the right host plants by ants. The first investigator records that nineteen genera of *Aphis*, at least, are subterranean, feeding on plant roots; some spend their entire life-cycles in the soil and some are restricted to certain host plants. He also adds that they occur to a depth of at least two feet and they are of general occurrence and stimulate ants to do a good deal of soil channelling in order to insure an adequate supply of food on which to maintain their honey-dew "cows".

The means per acre per annum of homopterous fauna extracted are shown in Figure 20. These means were higher in light clay soils than in clay loams. The

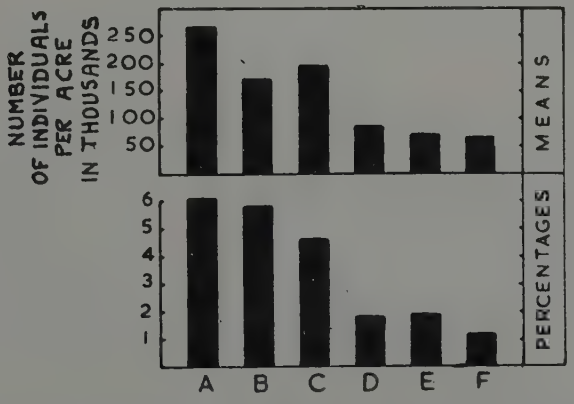

FIG. 20 : Means per acre per annum and percentages, in total insects of the homopterous fauna (A to F, fields examined; A to D, light clay soils; E and F, clay leam soils).

highest mean in fields of the former soil type was 265.000 specimens while it was 70.000 specimens in fields of the latter type. Percentages in total insects reached about 6% in light clay soils while they did not exceed 2% in clay loams.

Means per acre under various rotational periods are shown in Figure 15:5. With the exception of the mean under spring fallow in field (E), the means under

other fallows in all fields were lower than both the preceeding or succeeding crops. This showed the effect of green covering on the abundance of the fauna. The highest mean was 470.000 specimens under berseem in field (A).

Homopterous fauna was prevailing in the upper six-inch layer. In most cases, the number contained in the three-inch surface layer was greater than that existing in other layers combined.

In light clay soils, homopterous fauna were met with during two periods, viz. April-May and November-March. The highest monthly means in this soil type were under berseem either during December or February. These were 1.700.000 specimens, 900.000 specimens, 1.600.000 specimens and 600.000 specimens per acre in fields (A) to (D) respectively. The fauna in clay loams was comparatively very scarce. It was met with during May, December, February and March in field (E) where the highest monthly mean was 600,000 specimens per acre during May under tomato. The insects were found during June, November, December and March in field (F) where the highest mean was 900.000 specimens per acre during June under the green pear trees.

Homopterous fauna extracted were in the nymphal or apterous formes and were not identified to species. The prevailing genus was *Aphis*. Some nymphal specimens belonged to the family Pseudococcidae.

5. Hemiptera

Hemipterous faunal means per acre per annum are shown in Figure 21. The highest mean met with was 95.000 specimens in field (D). The effect of soil type on the faunal magnitude was not noticeable. Hemipterous percentages in total insects did not exceed 0.5% in most fields.

Concerning the means per acre under various rotational periods, as shown in Figure 15: 4, it could be noticed that these means under fallows were in general lower than the preceeding or succeeding crops. The highest mean was 175.000 specimens per acre under berseem preceeded by cotton.

With minor exceptions, hemipterous fauna was prevailing in the six-inch upper layer and, in most cases, the three-inch surface layer contained more specimens than found in other layers combined.

Hemipterous insects were met with during May, October and January in field (A) at a rate of 100.000 specimens per acre per month. They were found during April and February in field (B) at the same rate. In field (C) they were met with during March only at the same rate. The fauna was met with during September, December and March in field (D) where the highest mean was 1,300,000 specimens per acre during March under berseem. February was the only month during which

the fauna was met with in fields (E) and (F) at a rate of 200.000 specimens and 300.000 specimens per acre in the two fields respectively.

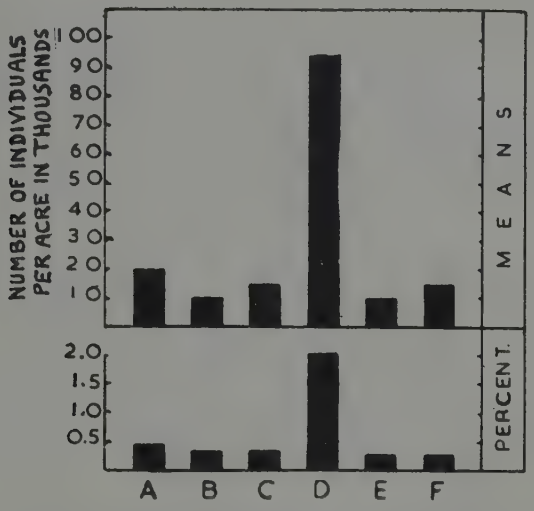

FIG. 21 : Means per acre per annum and percentages, in total insects of the hemipterous fauna (A to F, fields examined; A to D, light clay soils; E and F, clay loam soils).

Only three hemipterous species were extracted of which *Oxycarenus hyalinipennis* Costa formed alone 96.77% of the total hemipterous fauna. 19 specimens out of 31 individuals of this species were met with in field (D) where cotton had been growing. A large proportion of the nymphs of this species were obtained in a somewhat deformed state, denoting the possibility of their prior death before sampling. The fauna obtained were as follows :

(1) *Oxycarenus hyalinipennis* Costa : (a) Adults, D; 9 (4/I, II; 3/1). — (b) Nymphs, A, B, D, E; 9, 10, 12, 2, 3 (27/I, II; 10/1).

(2) *Xylocoris* sp., A; 5 (I/III).

(3) *Eusarcoris inconspicuus* (H.-S.), B; 4 (I/1).

6. Orthoptera

This order includes many species which spend varying periods of their life-cycles in the soil. They affect the soil, either by drilling holes in its surface to deposit eggs or by burrowing it in search of food (JACOT, 1940).

The means per acre per annum met with were low as shown in Figure 22. The highest mean was 35.000 specimens in field (C). Orthopterous fauna did not exceed 1% of the total insects in all fields.

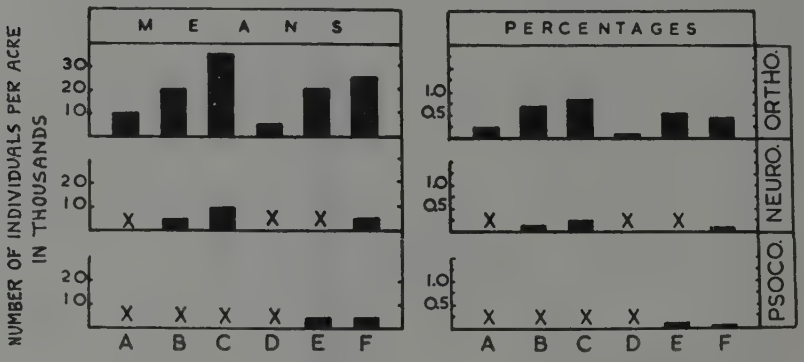

FIG. 22 : Means per acre per annum and percentages, in total insects of the orthopterous, neuropterous and psocopterous fauna (A to F, fields examined; A to D, light clay soils; A and F, clay leam soils; X, absence of fauna).

In contrast to previously mentioned orders, Orthoptera was only met with under fallow in fields (A) and (B), and its mean under fallow in field (C) was higher than both the preceeding and succeeding crops (Fig. 15:6). The highest mean was 60.000 specimens per acre under this latter fallow. The insects seemed to be attracted by bare land.

Orthopterous insects could penetrate the soil down to 15 inches below the soil surface. The tendency of them to prevail in a special strata was not noticeable.

Only two specimens of *Gryllotalpa gryllotalpa* L. were extracted from the stratum between 3 and 6 inches below the soil surface. Other orthopterous insects were in the nymphal stages and belonged to the family Acrididae.

The activities of orthopterous insects which make them able to escape during sampling are responsible to a far extent for their scarcity in the present estimation. The fauna was met with at various months of the year, especially those of autumn.

7. Neuroptera

Members of this order were only met with in three fields (B), (C) and (F). The highest mean per acre per annum was 10.000 specimens in field (C). Percentages in total insects did not exceed 0.24 % in any field. Like orthoperous faunes, Neuroptera was met with under fallows of fields (B) and (C) (Fig. 15:7). Though the summer fallow of this latter field was very dry, the highest faunal mean was found

under it (40.000 specimens). This denoted the tendency of such insects to invade bare and dry land. They could penetrate the soil down to 15 inches below the soil surface but there was a tendency for them to prevail the upper three surface inches. Neuropterous fauna were met with during July in field (B), during August in field (C) and during February in field (F.).

Only four individuals were extracted from 600 samples obtained from all fields. One specimen was in the adult stage and belonged to Hemerobiidae while the others were in the larval stages and belonged to Myrmelionidae.

8. Psocoptera

Few species of this order live on fragments of animal or vegetable matter, particularly on fungi and lichens.

Members of this order were only met with in clay loam soils. Means per acre per annum are shown in Figure 21. Means under various rotational periods are shown in Figure 15:9. They were met with only in the three-inch surface layer, during March in field (E) and February in field (F). Only two individuals were extracted from the 600 samples treated. They represented the genus *Lachesiella*.

IV. SUMMARY

(1) Insects belonging to the orders discussed in Part VII were extracted with other arthropod fauna but they were comparatively scarce especially in the case of Orthoptera, Neuroptera, Microlepidoptera and Psocoptera. Although the present discussion gives a conception about the magnitude, vertical distribution and annual fluctuations of these insects, yet better estimation requires an increase in sampling units.

(2) Means per acre per annum, means under various rotational periods, vertical distribution and monthly means were the main aspects from which the present insect orders were discussed.

(3) Contrary to other insect orders, Orthoptera, Neuroptera and Psocoptera seemed to prefer base land while other insects preferred soil under green covering.

V. ACKNOWLEDGMENT

The writer expresses his thanks to Prof. Dr. AHMED SALEM HASSAN, head of the Plant Protection Department of the Faculty of Agriculture, Cairo University, for his encouragement and criticism. Thanks are also due to Prof. Dr. H. PRIESNER, to Prof. Dr. M. HAFEZ and to Mr. A. ALFIERI for the kind help given in the identification of the insects recorded in this paper.

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IRAKISCHE KLEINSCHMETTERLINGE, II

(mit 10 Tafeln)

von Dr. H.G. AMSEL,

aus den Landessammlungen für Naturkunde Karlsruhe.

A. ALLGEMEINES

Herr Konsul E.P. WILTSHIRE, der beste Kenner der vorderasiatischen Macrolepidopteren, verliess 1956 Bagdad, wo er viele Jahre tätig war und übergab dem Verfasser nach seiner Rückkehr nach Europa wiederum das umfangreiche Microlepidopteren-Material, das er bis zu diesem Zeitpunkt im Irak eingetragen hatte. Soweit die Fänge aus den Jahren 1939-1953 stammen, wurden sie bereits in meiner Arbeit "Irakische Kleinschmetterlinge" (*Beitr. naturk. Forsch. SW.-Deutschl.*, XIV, pp. 119-129) 1955 bearbeitet und konnten von WILTSHIRE für seine umfassende Bearbeitung der Schmetterlingsfauna des Irak, die er unter dem Titel "The Lepidoptera of Iraq" 1957 in einer revidierten und erweiterten Auflage herausbringen konnte, noch mitberücksichtigt werden. Dagegen war es leider nicht mehr möglich, die neueren Ausbeuten der Jahre 1954-1956 in diese Fauna noch aufzunehmen, da das Material erst 1957 in meine Hände kam. So ist also diese Arbeit als Teil II der vorgenannten Veröffentlichung des Verfassers aufzufassen.

Das nunmehr bearbeitete Material stammt fast ausschliesslich aus dem kurdistanischen Gebirge, wo es in Haj Omran (= Hajji Omran), einem kleinen Dorf in 1700-1800 m Höhe, erbeutet wurde. Dieses Dorf liegt oberhalb von Rayat, nahe der iranischen Grenze östlich von Erbil (Arbil). Einige wenige Arten stammen aus Shaqlawa, das etwa 1000 m hoch im Zagros-Gebirge liegt sowie von einigen anderen Fundorten.

Es wurden insgesamt 31 neue Arten und 2 neue Unterarten gefunden, ausserdem war die Aufstellung von 3 neuen Gattungen notwendig. Es sind dies :

Chrysocrambus bleszynskii, *Mesocrambus kurdistanellus*, *Agriphila brioniella* f. *subbrioniella*, *Epidauria omranella*, *Shirazia wiltshirei*, *Ephestia irakella*, *Hypochalcia rayatella*, *Myrlaea kurdistana*, *Oligochroa nigroanalis*, *Acteniopsis kurdistanella*, *Nymphulosis arcanella*, *Epimetasia albalis*, *Platyptilia irakella*, *Alucita rayatella*,

Cnephasia nigripunctana, *Euxanthis subflavana*, *Euxanthis kurdistana*, *Laspeyresia coluteana*, *Dichrorampha obraztsovi*, *Glyphipteryx bifasciella*, *Pterolonche kurdistanella*, *Symmoca fuscella*, *Pleurota irakella*, *Pleurotopsis pygmaeella*, *Anacampsis malella*, *Metanarsia modesta kurdistanella*, *Ethmia kurdistanella*, *Ethmia rayatella*, *Tenuipenna simplicella*, *Catabola cornuta*, *Paratinea striaticostella*, *Paratinea irakella*.

Dis neuen Gattungen sind: *Acteniopsis*, *Nymphulosis* und *Tenuipenna*.

Diese Funde bedeuten also eine sehr wesentliche Erweiterung unserer systematischen und faunistisch-tiergeographischen Kenntnisse. Sie zeigen den grossen Reichtum der vorderasiatischen Fauna auch in diesem Teil sehr deutlich.

Sieht man sich die neuen Arten auf ihren wahrscheinlichen zoogeographischen Status hin an, so können die meisten ohne Schwierigkeiten und ohne Bedenken dem vorderasiatisch-mediterranen Faunenelement zugeordnet werden wie dies bei der Höhenlage des besammelten kurdistanischen Gebirges von vornherein zu erwarten war. Bei *Shirazia wiltshirei* dagegen wird es besser sein, sie dem iranisch-turanischen Faunenelement zuzuweisen. Tropischen Charakter dürften *Tenuipenna simplicella*, *Nymphulosis arcanella* und *Ephestia irakella* haben.

Auffallend ist für die bereits bekannten Arten der Ausbeute das sehr starke Zurücktreten der eurosibirischen Arten. Hier könnte mit einigem Vorbehalt nur *Phalonia posterana* Z. erwähnt werden. Man hätte für eine Höhenlage der kurdistanischen Gebirge von fast 2000 m. ein stärkeres Auftreten eurosibirischer Arten vermuten können. Bemerkenswert ist ferner, dass nur wenige Arten gefunden wurden, die bisher ausschliesslich aus Persien bekannt waren. Es sind dies *Phycita comeella* Ams., und *Epischnopsis nervosella* Rag. Nachdem aus Persien in den letzten beiden Jahrzehnten eine Fülle von Funden bekannt wurden, wäre es nur natürlich gewesen, wenn aus einem unmittelbaren Nachbargebiet wie Kurdistan eine grössere Anzahl dieser Funde ebenfalls gemeldet worden wäre. Dass dem nicht so ist, spricht für einen stark isolierten Charakter der dortigen Fauna. Auffallend ist ferner, dass zwei bisher nur aus dem westlichen Mittelmeergebiet bekannt gewesene Arten jetzt in Kurdistan aufgefunden werden konnten, nämlich *Aphelia* [*Tortrix*] *amplana* Dup. und *Depressaria campestrella* Chrét. Hervorgehoben sollen hier auch diejenigen Species werden, die bisher nur aus dem Raum der Levante (Libanon, Syrien, Palästina, Jordanien) bekannt waren, sodass diese Arten nunmehr als allgemein vorderasiatisch-mediterran angesprochen werden dürfen: *Chrysocrambus syriellus* Zy., *Homoeosoma nigrilimbella* Rag., *Monotonia straminella* Zy., *Nephopteryx mediterranella* Ams., *Aristotelia euprepella* Zy. und *Stagmatophora fulguritella* Rag.

Bei der Bestimmung einiger schwieriger Gruppen wurde ich in liebenswürdiger Weise von den Herren Dr. HANNEMANN für die Gattungen *Depressaria* und *Scythris*, von Dr. TOLL für die Coleophoriden und von Dr. PETERSEN für eine Anzahl fraglicher Tineiden unterstützt. Die Beschreibungen der neuen Tineiden und die dazugehörigen Strichzeichnungen der Genital-Armaturen übernahm Herr Dr. PETERSEN. Ihnen allen sei auch an dieser Stelle sehr herzlich gedankt.

B. SPEZIELLER TEIL

Pyralidae

Crambinae

Chrysocrambus bleszynskii, sp. n. (Taf, X, Fig. 1).

Spw. 22 mm. Cassentiniellus Z. *sehr ähnlich, etwas kleiner. Flügelfläche bis zur zweiten Querlinie gelblich getönt, dahinter weisslich. Apikales Feld mit zwei Längsstrichen, hierin* craterellus Sc. *ähnlich. Erste Querbinde weniger stark gebogen, zweite wesentlich stärker gebogen, vor der Costa dieser fast parallel. Längslinien breiter, am Saum mit schwarzen Punkten.*

Die Art ist gegenüber allen Verwandten daran sofort kenntlich, dass der Saumteil des Flügels bis zur zweiten Querbinde weisslich ist, während der übrige Flügel gelblich getönt erscheint. Die zweite Querbinde, die bei *cassentiniellus* fast senkrecht auf der Costa steht, beginnt bei *bleszynskii* an der Costa in der Weise, dass sie hier in weitem Bogen aus der Costa herauskommt, dieser also zunächst fast parallel verläuft. Das hierbei durchlaufene costale Feld ist weisslich ebenso das darunter befindliche, während der übrige Flügel durchaus gelblich getönt ist. Die Längsstriemen sind breiter als die hellen Zwischenräume, bei *cassentiniellus* ist es umgekehrt. Auch erreichen bei letzterer Art drei dieser Längsstriemen die erste Querbinde nicht, während bei *bleszynskii* nur eine (die mittlere) die erste Querbinde nicht erreicht.

Genitalapparat des Männchen (Taf. II, Fig. 1, 2): Valven kürzer und breiter, Costa stärker gebogen. Uncus nach der Basis zu kaum verbreitert. Gnathos breit und kurz. Anellus noch kleiner. Aedoeagus ohne Cornutus, kaum verschieden von *cassentiniellus*. GU. 3414.

Monotypus : 1 Männchen, Haj Omran, 2.-13.6.1956.

Ich widme die neue Art dem ausgezeichneten polnischen *Crambus*-Spezialisten Dr. St. Bleszynski, der sich um die Erforschung der Gattung *Crambus* grosse Verdienste erworben hat.

* *Chrysocrambus syriellus* Zerny.

Ein Männchen, Haj Omran, 2.-13.6.1956 (det. Bleszynski).

Bisher vom Libanon, Marasch und Deir-Ezzor (Mittellauf des Euphrat) bekannt.

Mesocrambus kurdistanellus, sp. n. (Taf. IX, Fig. 2).

Spw. 27 mm. Pallidellus Dup. *sehr ähnlich. Noch spitzflügliger. Die äussere Querbinde (eine innere fehlt !) setzt noch schräger an der Costa an, davor an der Costa befindet sich ein sehr schräger Costalstrich, der* pallidellus *fehlt. Der Verlauf der äusseren Querbinde vor den 3 Saumpunkten ist sehr ähnlich, aber etwas weiter vom Saum entfernt.*

Herr BLESZYNSKI, dem ich das Männchen einsandte, bestätigte mir, dass es sich hier um eine noch unbeschriebene Art handele zu der er folgendes bemerkte: "Valven terminal abgerundet (bei *pallidellus* enger, ziemlich zugespitzt). Lateral-Prozess deutlich kürzer, gerade (bei *pallidellus* etwas gebogen) Pars basalis ohne Fortsatz (bei *pallidellus* vorhanden). Die Zeichnung (Taf. I, Fig. 4) des Genitalapparates fertigte ich nach einer Bleistiftzeichnung BLESZYNSKI's an, für die ich auch an dieser Stelle sehr herzlich danke.

Holotypus : 1 Männchen, Hajji Omran, 25.7.54, 1760 m.
Allotypus : 1 Weibchen, Hajji Omran, 25.7.54, 1760 m.
Paratypus: 1 Männchen, Shaqlawa, 2500 ft., 30.6.1953.

Agriphila dalmatinella beieri Blesz.

Shaqlawa 3. und 13.10.1935, drei Männchen (det. BLESZYNSKI).

Pediasia contaminella Hb., f. n. oder ssp. ?

Shaqlawa, 16. 8. 1953, 1 Weibchen, über das mir Herr BLESZYNSKI folgendes mitteilte: "Vfgl. einheitlich hellockerfarben bräunlich. Mehrere kleine schwarze Punkte am Saum. Hfgl. glänzend schmutzig weiss, etwas grau getönt nach dem Apex zu, Fransen weiss. Genitalien mit der typischen Form übereinstimmend".

*** Agriphila brioniella subbrioniella f. n. BLESZYNSKI i. litt. (? species nova).**

Ein Weibchen zu dem mir Herr BLESZYNSKI folgendes schrieb: "Vfgl. einfarbig hell gelb, keine dunklen Flecke am Saum. Hfgl. glänzend hellgrau, Fransen weisslich. Ich besitze ein Weibchen dieser Form aus Syrien (Coll. Naturhistorisches Museum Wien) Dieses Weibchen hat Spuren einer ockerfarbenen Zeichnung ähnlich wie *brioniella* Zerny". Zum Genitalapparat (Taf. I, Fig. 5) bemerkt Herr BLESZYNSKI: "Ductus bursae beträchtlich breiter und stärker sklerotisiert auf einem kürzeren Stück als bei der typischen *brioniella*. Ein Signum".

Die Zeichnung verfertigte iche nach einer Strichzeichnung BLESZYNSKI's.

Ommatopteryx [*Eromene*] *islamella* Ams.

Bagdad, 14.10.1956, ein Männchen.

Ommatopteryx rayatella Ams.

Rayat, 30.7.1954, ein Männchen.

Ancylolomia tentaculella Hb.

Duri, Kurdistan, 12.10.1954, ein Männchen.

Ancylolomia palpella Schiff.

Shaqlawa, 23.6.20. und 30.9., 1.-12.10. Bemerkenswert ist das frühe Datum des 23.6! Die Weibchen variieren stark. Die meisten Exemplare haben eine gut entwickelte dunkle Faltenlinie, andere sind ganz zeichnungslos.

Schoenobiinae

Aeglotis argentalis Chr.

Haj Omran, 30.7.1954, ein Männchen.

Anerastiinae

Raphimetopus ablutella Z.
Bagdad, 12.7., 5.-18.10.

Ematheudes punctella vitellinella Rag.
Shaqlawa, 14.7., 2.10.1953.

Epidauria omranella, sp. n.

Spw. 20 mm. Der discella Rag. *sehr nahe, aber die rötlich-braune Beschuppung weniger stark und auf der axi ganz fehlend, wo bei* discella *ein rötlichbrauner Wisch vorhanden ist. Hfgl. dunkler grau.*

Genitalapparat des Männchens (Taf. III, Fig. 4): Uncus schmaler, costale Verstärkungsleiste der Valve bis zum Ende der Valve durchgehend, Costa im Gesamtverlauf ganz gerade, Valve nach dem Ende zu stärker verschmälert. Bei zwei Präparaten der *discella* aus Persien fand ich eine costale Verstärkungsleiste, die nur bis zur Hälfte der Valvenlänge reicht. Es muss offen bleiben, ob bei reichlicherem Material beider Arten vermittelnde Übergänge auftreten werden, was nicht ausgeschlossen ist. Vorläufig empfiehlt es sich, die Art als bona species anzusehen.

Monotypus : 1 Männchen, Hajji Omran, 30.7.54.

Shirazia wiltshirei, sp. n. (Taf. X, Fig. 4).

Spw. 29 mm. Von *monotona* Ams. 1953 (*Ark. f. Zool.*, Bd. IV, Nr. 16, p. 269, Fig. 59, 60) äusserlich kaum zu trennen. Im Hfgl. sind aber m^2 und m^3 viel länger gestielt, der gemeinsame Stiel ist etwa 5-6 mal so lang wie die freien Äste (bei *monotona* nur etwa 1 1/2 mal so lang !). Fühlerbewimperung und Palpen wie bei *monotona*. Costa und vor allem der Saum der Vfgl. stärker gerundet.

Genitalapparat des Männchens (Taf. I, Fig. 1): Gnathos-Ende weniger breit, Costalhöcker der Valven kleiner, Vinculum viel weniger breit abgestutzt. Aedoeagus von der Mitte ab stark verbreitert (bei *monotona* stabförmig, parallelrandig) mit charakteristischen inneren Strukturen. GU. 3415.

Monotypus: 1 Männchen, Haj Omran, 5.8.1954.

Saluria maculivittella Rag.
Bagdad, 29.5.1956.

Phycitinae

Heterographis rhodochrella f. *hellenica* Stgr.
Bagdad, 3.10. Ein Stück, das mehr zur Nominatform zu stellen ist aus Shaqlawa, 3.7.

Heterographis subcandidatella Rag.
Bagdad, 14.5.1956, ein Weibchen.

Heterographis bichordella Rag.

Shaqlawa VI. 1953, zwei Exemplare.

* *Homoeosoma nigrilimbella* Rag.

Hajji Omran, 26.7.54, ein Männchen von 16 mm. Spw.

Ephestia calidella Gn.

Bagdad, 24. 4.1955. GU. 3411.

Ephestia irakella, sp. n.

Spw. 14 mm. Vfgl.-Grundfarbe grau, Querbinden wenig auffallend. Erste dunkle Querbinde senkrecht auf der Costa bei $^1/_3$, ganz gerade, nur wurzelwärts schärfer begrenzt, äussere helle, gewellte Querbinde parallel dem Saum, 5-6 unbedeutende Saumflecke. Hfgl. hell, oberhalb der Basis von cu^2 ein strichartiges kleines Feld abweichender glänzender Beschuppung. Cubitalkamm mit wenig dichter, aber langer Behaarung, Analkam mit kurzer, dichter Behaarung.

Die Art gehört in diejenige Gruppe der Ephestien, bei denen auf der Vfgl.-Unterseite die Costa an ihrer Basis einen Haarkamm trägt, der hier grau ist mit schwacher gelblicher Beimischung. Im Hfgl. entspringen cu^1 und $m^2 + ^3$ von der hinteren Zellecke (wie bei *figulilella* Gregs.) Äusserlich am bemerkenswertesten und die Art am besten charakterisierend ist das kleine strichartige Feld abweichender Beschuppung oberhalb der Basis von cu^2, das bei bestimmter Beleuchtung metallisch glänzt. In anderer Belichtung wirkt es wie eine unbeschuppte Stelle. Bei keiner anderen Ephestie ist mir eine solche Erscheinung bisher begegnet. Die Zeichnung ist unscheinbar, die Art sehr schmalflüglig, an *figulilella* erinnernd, aber noch kleiner.

Genitalapparat des Männchens (Taf. II, Fig. 3) : Mit *cautella* Wlk. am nächsten verwandt, aber die Seitenarme des Tegumens viel schlanker und länger, bis zur Spitze des Gnathos reichend. Gnathos viel flacher. Zahn der Costa sehr ähnlich in Lage, Grösse und Stellung. Valven etwas schmaler. Aedoeagus kürzer, Beschuppung des 8. Segmentes ähnlich. GU. 3409.

Monotypus : 1 Männchen, Bagdad, 24.5.1954.

Ephestia cautella Wlk.

Shaqlawa, 10.7.1953, Bagdad, 10.-18.3., 7.4. (GU.).

Psorosa nucleolella Mschl.

Shaqlawa, 4.7.1953. GU. 3413 (Weibchen), 12.7.1953, ein Weibchen.

Aproceratia rhectogramma Meyr.

Hajji Omran, 31.7., ein Männchen.

Hypochalcia rayatella, sp. n. (Taf. IX, Fig. 3-5).

Spw. 26-31 mm. Vfg. lehmfarben, Costa und Innenrand überwiegend dunkel. Zellschlussfleck fehlend. Erste dunkle Querbinde fast rechtwinklig auf der Falte

geknickt, zweite Querbinde fast gerade. Adern ± dunkler angelegt. Fransen dunkel, glänzend. Hfgl. dunkelbraun. Fransen mit dunkler Basallinie, sonst hell. Palpen 4 mal so lang wie der Augendurchmesser, dunkel, fast schwarz, glänzend. Erstes Glied hell, zweites unterseits hell.

Die Art ist durch die ganz gerade äussere Querbinde, die von einer hellen Querbinde der lehmfarbenen Grundfarbe begleitet wird und die rechtwinklig gebogene erste Querbinde gut charakterisiert. Die erste Querbinde ist kräftiger und deutlicher als die zweite, sie beginnt bei 1/3 Costa und stösst auf den Innenrand bei 1/2. Die zweite Binde erreicht den Innenrand genau in der Mitte zwischen Saum und erster Binde. Beide Binden können auch fast fehlen, wie dies beim Holotypus der Fall ist. Basalglied der Fühler und die darauf folgenden 5 weiteren Fühlerglieder wie die Palpen schwarz und metallisch glänzend. Fühler pubescent. Unterseiten der Vfgl. mit heller Costa, sonst bis zur zweiten Binde verdunkelt, dahinter wieder heller. Hfgl.-Unterseite fast wie die Oberseite, am Apex etwas aufgehellt. Der gemeinsame Stiel von m^3 und m^2 so lang wie die freien Äste.

Genitalapparat des Männchens (Taf. III, Fig. 6) : Uncus breit und kurz. Tegumen-Fortsätze nach dem Ende zu verbreitert, dann wieder schmaler werdend, abgerundet. Valven fast parallelrandig. Anellus spitz dreieckig, an der Basis seitlich mit je einer schwach beborsteten Warze. Aedoeagus röhrenförmig, schmal, lang, am terminalen Ende seitlich verbreitert, ohne Cornuti. GU. 3417.

Die Art gehört in die Gruppe der Arten, bei den die Aussenbinde gerade verläuft und kann daher bei *fasciatella* Stgr. eingeordnet werden. Diese ist erheblich kleiner, die Querbinden stehen näher beieinander und die erste Binde ist viel weniger stark gewinkelt.

Holotypus : 1 Männchen, Haj Omran, 2.-13.6.1956.
Paratypus : 2 Männchen, Haj Omran, 2.-13.6.1956.

Euzophera pulchella Rag.
Shaqlawa, 31.7.1953.

Pristocera solskyi Chr.
Haj Omran, 26.7.1954.

* *Monotonia straminella* Zy.
Hajji Omran, 26.-30.7.1954, acht Weibchen.

Adelosemia crepusculella Led.
Haj Omran, 2.-13.6.1956, 25. und 31.7.1954.

Candiope uberalis Sw.

Bagdad, 3.10. MARTIN bildet in *Pyralis* 3 v. 24.3.1956 den Typus von *Elithya buxtoni* Rthsch. ab. Die gute fotographische Wiedergabe dieser Art zeigt meines Erachtens ohne jeden Zweifel, dass dies ein Synonym von *uberalis* ist.

Nephopteryx rhenella laetifica Rag.
Shaqlawa 14. und 31.7.1953.

Nephopteryx divisella Dup.
Shaqlawa, 6.7.1953.

* *Nephopteryx mediterranella* Ams.
Bagdad, 27.11.1956, ein Weibchen.

* *Phycita comeella* Ams.
Hajji Omran, 26.-31.7.1954, 3 Männchen, 3 Weibchen. Shaqlawa, 5-.16.7.53.
Die Art war bisher nur aus Persien bekannt.

Epiepischnia pseudolydella Ams.
Haj Omran, 2.-13.6.1956, ein Männchen.

* *Epischnopsis nervosella* Rag.
Mt. Algord, 11.000 ft., 7.8.1954 (Kurdistan).

Myrlaea albistrigata Stgr.
Hajji Omran, 25.-27.7. 1954.

* *Myrlaea epischniella* Stgr.
Hajji Omran, zwei Männchen von 28 mm. Spw. am 25.7.54.

Myrlaea kurdistana, sp. n. (Taf. X, Fig. 3)

Spw. 21-24 mm. Vfgl. grau-bräunlich, Costa stark weisslich. Nahe der Basis von ax^1 und ax^2 zahlreiche schwarze Schuppen und auch zwischen den beiden Adern an dieser Stelle. Äussere Querlinie durch dunkle, aussen weisslich angelegte waagerechte Strichel, kurz vor dem Apex beginnend und nach $^3/_4$ des Innenrandes führend, angelegt. In der Falte ist die Linie unterbrochen. Dunkle Saumlinie sehr fein, Fransen weisslich. Hfgl. hellgrau, Saumlinie sehr fein. Palpen hellgrau, Endglied sehr klein. Vfgl.-Unterseite bis $^2/_3$ Costa mit schwarzen Schuppen, auf den Hfgl. bis $^1/_3$ reichend.

Die Art steht *epischniella* Stgr. (27-29 mm.) nahe, ist aber kleiner und durch die dunklen Schuppen auf der ax^1 und ax^2 sehr gut charakterisiert. Unterseits sind die dunklen Schuppen besonders auf den Hfgl. stark entwickelt. Sie nehmen den Raum zwischen Costa und oberer Zellgrenze fast ganz ein und sind sogar längs der unteren Zellgrenze noch schwach entwickelt. Bei *epischniella* sind sie nur längs der Costa bis 1/6, längs der oberen Zellgrenze doppelt so breit und fehlen ganz im Raum dazwischen und auch völlig auf der unteren Zellgrenze.

Genitalapparat des Männchen (Taf. I, Fig. 3) : Valve schmal mit gut entwickeltem Clasper bei 1/4. Aedoeagus röhrenförmig mit rechtwinklig am Ende abbiegendem spitzen Cornutus. Culcita ohne pferdekopfartiges Schuppenpaar. GU. 3406.

Der Genitalapparat von *epischniella* (Taf. III, Fig. 3) ist in Bezug auf die eigentliche Armatur kaum von *kurdistana* verschieden, lediglich der Aedoeagus

ist etwas länger. Dagegen ist die Culcita durch die abweichende Schuppenbildung, die andere Gestalt des zentralen Mittelstückes, das hier an der Basis eine deutliche Ausbuchtung zeigt, deutlich verschieden.

Holotypus : 1 Männchen von 21 mm. Spw., Shaqlawa, 19.6.1953.

Allotypus : 1 Weibchen von 24 mm. Spw., Shaqlawa, 6.7.1953, bei dem die dunklen Schuppen auf den Axillaradern viel schwächer entwickelt sind.

Anmerkung: Die von mir beschrieben *Salebria*-Arten *minicralis*, *pittionii*, *nigrosquamalis* (*Ark. f. Zool.*, Bd. I, Nr. 17, p. 230-232, 1950) sind zu *Myrlaea* Reg. (Typus: *epischniella* Stgr.) zu stellen. Das gleiche trifft für *albistrigata* Stgr. zu. Alle diese Arten haben den für *epischniella* typischen Genitalapparat mit dem quer zum Aedoeagus stehenden Cornutus.

Oligochroa dionysia Z.

Bagdad, 18.3., 8. und 15.4., 1. und 19.8., 24.9., 16.10.

Oligochroa nigroanalis, sp. n. (Taf. X, Fig. 2).

Spw. 18-21 mm. Basis des letzten Abdominalsegmentes beim Männchen mit schwarzen Schuppen, Abdomen sonst grau. Vfgl.-Grundfarbe hellgrau, schwärzliche Schuppen ziemlich dicht aufgetragen, etwas gehäuft auf den Adern, lehmfarbene Schuppen am Innenrand und in der Falte. Äussere Querbinde ganz schwach angedeutet. Schwarze Schuppen auf der Vfgl.-Unterseite längs der Costa bis $^1/_4$, zwischen Costa und Zellgrenze bis fast $^1/_2$. Hfgl.-Unterseite mit wenigen schwarzen Schuppen längs der oberen Zellgrenze.

Die Art erinnert stark an *sordida* Stgr., doch fehlen dieser die schwarzen Schuppen am Hinterleibsende und auf den Unterseiten der Flügel. Palpen beim Männchen an die Stirn angedrückt, diese etwas überragend, hellgrau und dunkelgrau gemischt. Maxillarpalpen gross, gelblich. Beim Weibchen sind die Palpen weniger stark an die Stirn angedrückt, eher etwas vorgestreckt oder aufgebogen, letztes Glied viel länger (1/5 des 2.) als beim Männchen. Fühler des Männchens abgeplattet. Bewimperung 1/4, Beschuppung oberseits fast weiss.

Die unscheinbare Art hat kaum eine nennenswerte Zeichnung, Zellschlusspunkte und äussere Querlinie sind kaum angedeutet. Im Geäder stehen m^2 und m^3 sehr nahe beieinander, Hfgl. mit gestielter m^2 und m^3; cu^1 kurz gestielt auf m^{2+3}; cu^2 nahe der Zellecke. Haftborste des Weibchens einfach! Ventral- und Lateralseiten des Thorax ohne schwarze Schuppen.

Genitalapparat des Männchens (Taf. I, Fig. 2): Gnathos klein, seitlich stark verbreitert. Costa der Valven bei $^1/_2$ mit einem kleinen Zahn, Valven basal stark verbreitert, Aussenteil sehr schmal und schwach chitinisiert. Aedoeagus mit einem grossen Cornutus und zwei Seitenreihen kleiner Cornuti am terminalen Ende. Culcita mit einfachen Haaren. Dorsale Schuppe des letzten Segmentes, die mit der Culcita in Verbindung steht, mit schwarzen Schuppen grösstenteils besetzt. GU. 3407.

Holotypus : 1 Männchen, Shaqlawa, 15.7.1953.

Allotypus : 1 Weibchen, Schaqlawa, 7.7.1953.

Paratypus : 1 Männchen und 1 Weibchen, Shaqlawa, 16.8.1953.

Ich stelle die Art zu *Oligochroa* Rag. (Typus: *dionysia* Z.) obwohl der Genital-Apparat einige bemerkenswerte Abweichungen gegenüber *dionysia* zeigt. Doch stimmen alle sonstigen Merkmale wie Geäder, Palpen- und Fühlerbildung so gut überein, dass von einer Abtrenrung abgesehen werden soll.

Praesalebria lepidella Rag.
Haj Omran, 2.-13.6.1956.

Praesalebria argyrophanes Meyr.
Shaqlawa, 30.6.1953, 14.7., 16.8.

* *Praesalebria noctivaga* Stgr.
Hajji Omran, 1.8. (1).

Myelois circumdatella Led.
Haj Omran, 2.-13.6.1956.

Myelois pumicosa Led.
Haj Omran, 2.-13.6.1956. Gora-Shala, 700 ft., 29.3.1956, 1.4.1956.

Myelois synclina Meyr.
Shaqlawa, 12.7.1953. Ein Weibchen, sehr schlecht erhalten, das mit dem ebenfalls schlecht erhaltenen weiblichen Typus gut übereinstimmt.

Myelois cinerea Stgr.
Shaqlawa, 13.7.1953.

Pyralinae

ACTENIOPSIS, n. gen.

Stemmata und Rüssel vorhanden. Maxillarpalpen sehr klein, Labialpalpen vorgestreckt, ziemlich kurz, Fühler des Männchens lang zweireihig bewimpert, Fühler des Weibchens schwach pubescent. Stirn glatt, mit unbedeutendem Schuppenbusch. Vfgl.-Geäder: r^2 aus der Zelle, m^1 kurz gestielt auf $r^3 + ^4 + ^5$, letztere drei Adern fast aus einem Punkt, beim Weibchen mitunter r^{4+3} sehr kurz gestielt auf r^5, m^2 und m^3 aus einem Punkt. Axillaris nicht gegabelt. Hfgl.-Geäder: m^2 und m^3 aus einem Punkt, *rr* und *sc* stark genähert.

Genitalapparat des Männchens: Vom *Pyralis*-Typus.

Typus: *Acteniopsis kurdistanella*, sp. n.

Die neue Gattung hat den Habitus von *Actenia* Gn. (Typus: *honestalis* Tr.), hat aber sehr kleine, kaum erkennbare Maxillarpalpen und abweichende, viel kürzere, breiter beschuppte Labialpalpen. Das Flügelgeäder ist ähnlich, im Hfgl. kommen m^2 und m^3 aus einem Punkt, während bei *Actenia* diese kurz gestielt sind. Im Vfgl. ist bei *Actenia* $r^5 \pm$ lang gestielt auf $r^3 + ^4$. Die Fühlerbewimperung

(1) *Salebria neftaella* Luc. liegt aus Am Riga nördöstlich von Aden (SW.-Arabien) in einem Exemplar (leg. Popov) vor. Dieser interessante Fundort kann hier beiläufig mit erwähnt werden.

ist auch abweichend: bei *Actenia* stehen zwei Reihen kräftiger Wimperbüschel, deren Enden in zahlreich Haare gespalten sind, auf dem Fühler, bei *Acteniopsis* sind die Wimpern sehr zart, am Ende in wenige feine Haare gespalten.

Acteniopsis kurdistanella, sp. n. (Taf. X, Fig. 5).

Spw. 17-18 mm. Fühlerbewimperung 1,5. Vfgl.-Grundfarbe blass lehmfarben, Zellschlussfleck fehlend, die beiden Querbinden und die Costalstrichel braun-rötlich. Hfgl. kaum dunkler, zeichnungslos.

Labialpalpen 1 $^1/_2$ so lang wie der Augendurchmesser, lehmfarben-bräunlich, oberseits weisslich wie die Stirnschuppen. Erste Querbinde sehr schwach, bei $^1/_4$, gerade, zweite deutlich, von $^3/_4$-$^4/_5$ Costa nach dem Innenwinkel, ganz schwach s-förmig. Costalstrichel von der Wurzel bis zur zweiten Querlinie. Vfgl.-Unterseiten und schwächer auch die Hfgl. mit rötlichbraunen Schuppen.

Genitalapparat des Männchens (Taf. III, Fig. 2): Uncus wenig höher als breit, parallelrandig, Vinculum kurz zugespitzt. Cornutus ankerartig am terminalen Ende des Aedoeagus. GU. 3412.

Holotypus : 1 Männchen, Hajji Omran, 31.7.1954.
Allotypus : 1 Weibchen, Hajji Omran, 27.7.1954.
Paratypus : 1 Weibchen, Hajji Omran, 1.8.1954.
Alle Exemplare sind ziemlich schlecht erhalten.

Bostra marginalis Rthsch.
Bagdad, 13.5., 3.8., 7.10.

Macalla lophotalis Hmps.
Shaqlawa, 12.-17.7.1953, 5 Weibchen (2).

Pyraustinae

Cybalomia pentadalis Led.
Bagdad, 8.4.

Prochoristis rupicapralis Led.
Rowanduz Gorge, 14.6.1956, 700 m.

NYMPHULOSIS, n. gen.

Costa der Vfgl. ziemlich gerade, Saum bei m^2 leicht eingebuchtet. Saum der Hfgl. zwischen m^2 und m^3 leicht eingebuchtet. Habitus zart, an Nymphuliden-Gattungen erinnernd. Palpen vorgestreckt, Maxillarpalpen gross, pinselförmig. Rüssel normal. Nebenaugen fehlen. Fühler kurz bewimpert. Hfgl. mit deutlichem

(2) *Crocalia aglossalis* Rag. liegt mir aus Am Riga einem Fundort nördöstlich von Aden (SW-Arabien) vor, was an dieser Stelle mitveröffentlicht werden kann.

Haarkamm auf dem Cubitalstamm. Vfgl.- Geäder: r^1 gegenüber cu^2, r^2 unmittelbar neben r^3; r^3 und r^4 aus einem Punkt oder ganz kurz gestielt, r^4 in die Spitze, r^5 deutlich unterhalb $r^3 + ^4$, m^1 fehlend, m^2 und m^3 aus einem Punkt von der unteren Zellecke, cu^1 nahe de Zellecke, cu^2 weit von cu^1. Transversale nur an den Zellecken deutlich, sonst fast fehlend, die Zelle daher fast offen. Hfgl.-Geäder: *sc* und *rr* nicht sehr lang gestielt, m^1 mit Querverbindung zum Stiel von *sc* und *rr*; m^2, m^3 und cu^1 aus einem Punkt.

Genitalapparat des Männchens: Valven breitflächig, ohne Auszeichnungen. Aedoeagus röhrenförmig, fest mit der Armatur verbunden. Uncus, Tegumen und Vinculum fehlen.

Die Stellung der Gattung im System muss vorläufig noch offen bleiben. Die fehlende Ader m^1 im Vfgl. und der sehr merkwürdige Genitalapparat des Männchens weisen auf eine isolierte Stellung hin.

Typus : *Nymphulosis arcanella*, sp. n.

Nymphulosis arcanella, sp. n. (Taf. IX, Fig. 11).

Spw. 15 mm. Vfgl.-Grundfarbe grau, seidig glänzend. Erste Querbinde bei $^1/_3$, unscharf, mit gelblicher Makel an der Costa beginnend, zweite helle Querbinde deutlich, gewellt. Zwei gelbliche, längliche Makeln an der Costa hinter $^1/_2$. Zellschlussfleck wenig deutlich. Dunkle Saumlinie fein. Hfgl. nach der Wurzel zu hell, eine helle Querbinde von $^3/_4$ Costa zum Innenwinkel, Saumteil verdunkelt, von der feinen Saumlinie aufgehellt. Fransen mit dunkler Teilungslinie.

Die erste fast gerade Querlinie geht von $^1/_4$ Costa nach $^1/_5$ Innenrand. Die erste Costalmakel hinter der Mitte der Costa ist grösser als die unmittelbar folgende. Die Makel bei Beginn der zweiten Querlinie ist als solche kaum noch erkennbar. Palpen grau-schwärzlich, drittes Glied $^1/_3$ des zweiten. Maxillarpalpen bis fast zum Ende des zweiten Labialpalpengliedes reichend. Fühlerbewimperung $^1/_2$.

Genitalapparat des Männchens (Taf. III, Fig. 1): Der Aedoeagus ist ganz fest mit der Armatur verbunden und kann aus der Armatur nicht herausgezogen werden. Ductus ejaculatorius sehr weit terminal endigend. Cornuti fehlen, einige innere Strukturen sind (S) sichtbar besonders, auffällig in zwei parallelen säulenartigen Gebilden am Ende des Aedoeagus. Ob diese Strukturen allerdings noch zum Aedoeagus gehören, mag dahingetellts bleiben, wie denn überhaupt die ganze Armatur rätselhafter Art ist. Tegumen, Uncus und Vinculum können nicht festgestellt werden. Es kann sein, dass Uncus und Tegumen in häutiger Form vorhanden waren und beim Kochen in KOH unsichtbar wurden. Ohne weiteres Material muss eine Deutung der merkwürdigen Armatur zunächst unterbleiben. GU. 3416.

Synclera traducalis Z.
Shaqlawa, 4.8.

Epactoctena octogenalis Led.
Shaqlawa, 20.6.1953.

Metasia suppandalis Hb.
Haj Omran, 25.7., 1.8.1934.

Hellula undalis F.
Bagdad, 8.4., 18.5.

Antiercta ornatalis Dup.
Bagdad, 10.3., 22.9.

Pachyzancla licarsisalis Wlk.
Bagdad, 28.12.1955.

Loxostege nudalis Hb.
Bagdad 15.5. und ex. l. *Amaranthus graecizans*, 20.9.

Pyrausta virginalis f. *auroralis* Z.
Haj Omran, 2.-13.6.1956.

Udea [*Pionea*] *confinalis* Led.

Haj Omran, ex. l. Distel (thistles), 23.6. 1956. Die Stücke sind deutlich blasser gelb als solche vom Elburs-Gebirge.

Mecyna amasialis Stgr.
Shaqlawa, 31.5.1954.

* *Mecyna* [*Pyrausta*] *trinalis* Schiff.

Haj Omran, 2.-13.6.1956, ein Männchen von 28 mm. Spw., das von österreichischen Stücken kaum verschieden ist. Die in der Fauna von WILTSHIRE aufgeführte *trinalis* ssp. *pontica* Stgr. ist eine bona species !

Mecyna lutulentalis Led.
Haj Omran, 27.7.1954.

Aeschremon disparalis HS.
Bagdad, 2.5.1956.

Phlyctaenodes sinuosalis Le Cerf
Haj Omran, 26.7.1954 und aus einem unleserlichen Fundort von nur 4000 ft. Höhe vom August 1954.

Phlyctaenodes pustulalis Hb.
Haj Omran, 2.-13.6.1956.

* *Euclasta splendidalis* HS.
Shaqlawa 30.6.1953, ein Männchen (GU. 724 WILTSHIRE).
Der Aedoeagus der Art hat einen viel kürzeren Cornutus als *mirabilis* Ams. Nur durch das Genital-Präparat war die Art als hierher gehörig zu erkennen, da der Falter sehr schlecht erhalten war.

Anania [*Pionea*] *verbascalis* Schiff.
Shaqlawa, 5.8.1954, ein schlecht erhaltenes Stück.

"*Pyrausta*" *ochrifascialis* Chr.
Bagdad, 28.5.1955.

Cynaeda gigantea Wck.
Haj Omran, 25.7.
Die Stücke sind fast durchweg ölig, sodass wohl auf eine abweichende Lebensweise der Raupe gegenüber unserer nicht ölig werdenden *dentalis* Hb. geschlossen werden darf.

Epimetasia albalis, sp. n.

Spw. 17-18 mm. Vfgl. weisslich, fast zeichnungslos, eine ganz schwach angedeutete, wie bei Emprepes eoa Meyr. *verlaufende gelbbräunliche Linie ist nur über dem Innenrand bei* $^3/_4$ *und von dort bis* cu^1 *sichtbar. Fransen weiss, Hfgl. weisslich.*

Herr Konsul WILTSHIRE bestimmte diese Art als *vestalis* Rag. *Vestalis* wurde nach einem Männchen aus Mardin (östliche Türkei) beschrieben. Nach sorgfältigem Vergleich mit der Originalbeschreibung komme ich jedoch zu dem Ergebnis dass hier eine noch unbeschriebene Art vorliegen muss. *Vestalis* ist mit 20 mm. Spw. grösser und ist schwefelfarben. Die Fransen sind bleich-gelb, die Enden der Fransen weiss. Die Hfgl. sind nach dem Rande zu verdunkelt. Alle diese Angaben passen nicht auf die beiden vorliegenden Stücke.

Fühlerbewimperung $^1/_2$, beim Weibchen kaum kürzer. Labialpalpen vorgestreckt, anliegend beschuppt, etwas länger als der Kopf, weisslich, zweites Glied kaum gelblich angeflogen. Maxillarpalpen weisslich, bis zum Ende des zweiten Labialpalpengliedes reichend, mit feinen gelbbräunlichen Borsten des ersten Gliedes. Chitinplatte vor den Augen sehr klein, ohne Zahn; Stirn ohne Vorsprung, glatt begrenzt, sehr ähnlich wie bei *Emprepes* Led. Kopf, Thorax, Schulterdecken, Abdomen fast weiss. Die gelbbräunliche Linie der Vfgl. ist ohne Lupenbetrachtung unsichtbar. Sie beginnt bei $^3/_4$ des Innenrandes und führt im leichten Bogen bis cu^1. Unterseiten der Vfgl. weissgrau, Fransen rein weiss, ohne Teilungslinie (Auch oberseits ohne Teilungslinie !). Hfgl.-Unterseiten heller weissgrau, Fransen weiss.

Genitalapparat des Männchens (Taf. III, Fig. 5) Vom *Tegostoma*-Typus: Aedoeagus ziemlich kurz und dick, ohne Cornuti. Valven-Innenrand stark nach aussen gewellt. GU. WILTSHIRE, Nr. 611, Präparatensammlung AMSEL Nr. 3427.

Holotyp s : 1 Männchen, Shaqlawa, 30.9.1953.

Allotypus : 1 Weibchen, Shaqlawa, 3.7.1953.

Die Gattung *Epimetasia* Rag. steht *Emprepes* Led. sehr nahe, ist aber von dieser durch den fehlenden Rüssel verschieden. *Emprepes eoa* Meyr. ist auf Grund dieser Tatsache auch zur Gattung *Epimetasia* zu stellen.

Pterophoridae

Emmelina monodactyla L.
Duri (Kurdistan), 14.10.1954.

Platyptilia irakella, sp. n. (Taf. X, Fig. 9).

Spw. 22-25 mm. Vfgl.-Grundfarbe gelbbräunlich, dunkler als bei *ochrodactyla* Hb., heller als bei *gonodactyla* Schiff., ohne Ausbildung eines dunklen Costaldreiecks wie bei *gonodactyla, zetterstedti*, etc., mit zwei feinen dunklen Punkten vor dem Spaltengrund. Costa bis kurz vor die Spalte überwiegend bräunlich. Dicht vor der Spalte ziemlich breit aufgehellt, dann anschliessend wieder dunkler. Bei $^2/_3$ bis $^3/_4$ des Zipfels ein heller Querstrich, der sich auf den zweiten Zipfel fortsetzt. Fransen des ersten Zipfels aussen an der Basis bräunlich, sonst weisslich, am Innenwinkel in ganzer Länge dunkelbraun. Am Innenrand zum Spaltengrund hin überwiegend weisslich. Fransen des zweiten Zipfels entsprechend. Innenrandsfransen des zweiten Zipfels unterhalb des Spaltengrundes einmal und bei $^4/_5$ des ganzen Innenrandes ein zweites Mal dunkel durchschnitten, sonst hell. Zweiter Zipfel nach aussen nicht verbreitert, also schmaler als bei *gonodactyla*, hierin mit *ochrodactyla* übereinstimmend. Schuppenfleck der 3. Hfgl.-Feder kleiner als bei *gonodactyla*, aber in gleicher Lage. Unterseiten des ersten und zweiten Vfgl.-Zipfels mit hellem Querstrich, erster Zipfel des Hfgl. mit breitem Querstrich, der schräger als auf den Vfgl.-Zipfeln liegt. Stirnbusch so lang wie der Augendurchmesser, Palpen doppelt so lang, hellbräunlich. Fühler hell und dunkel geringelt, Bewimperung $^1/_3$.

Genitalapparat des Männchens (Taf. I, Fig. 6) : Uncus als kräftiger Haken entwickelt. Sacculus sehr schnell an Breite verlierend, aber bis 4/5 des Aussenrandes der Valve reichend. Aedoeagus schnabelartig gebogen GU. 3365.

Holotypus : 1 Männchen, Haj Omran, 2.-13.6.1956.

Allotypus: 1 Weibchen, Haj Omran, 2.-13.6.1956.

Paratypus: 6 Männchen und Weibchen, Haj Omran, 2.-13.6.1956.

Die Art variiert ziemlich stark hinsichtlich der Intensität der hellen und dunklen Farbtöne. Sie hat nichts mit der auch aus dem Irak beschriebenen *leucocrossa* Meyr. zu tun.

Alucita rayatella, sp. n.

Spw. 19-22 mm. Der *tetradactyla* L. und besonders der *baliodactyla malacodactyla* Z. zum Verwechseln ähnlich. Fransen aller Zipfel einheitlich bräunlich. Grundfarbe der Vfgl. genau mit *malacodactyla* übereinstimmend, Thorax und Abdomen jedoch deutlich etwas ins Grüngelbliche spielend und dadurch bei sauberen Stücken auch ohn GU sicher von den Genannten zu unterscheiden.

Genitalapparat des Männchens (Taf. V, Fig. 2): Rechte Valve wesentlich kleiner als die linke und mit einer hinter der Mitte stark zurücktretenden Costa. Sacculus als langer Ast bis zum Apex reichend, nach dem Ende zu stark verjüngt und zweimal gebogen. Linke Valve fast doppelt so breit wie die rechte. Sacculus-Ast bis zur Costa gehend, nur ganz unbedeutend gebogen, fast gerade, GU. 3336.

Holotypus: 1 Männchen, Haj Omran, 2.-13.6.1956.

Allotypus: 1 Weibchen, Haj Omran, 2.-13.6.1956.

Paratypus: 2 Männchen und 1 Weibchen, Haj Omran, 2.-13.6.1956.

Oxyptilus sp.

Aus Haj Omran, 2.-13.1956, liegt ein Exemplar von 20 mm. Spw. ohne Abdomen vor, das nicht bearbeitet werden konnte. Ein Weibchen der gleichen Art von 17 mm. Spw. liegt vom Mt. Algord, 11000 ft., 2.8.1954 vor.

Tortricidae

Archips [*Cacoecia*] *rosana* L.

Bagdad, ex 1. *Populus euphratica*, 13.4.1956.

* *Aphelia* [*Tortrix*] *amplana* Dup.

Haj Omran, 2.-13.6.1956, ein Pärchen.

Tortrix viridana L.

Haj Omran, 2-13.6.1956, 4 Weibchen und 2 Männchen.

Tortricomorpha shaqlawana Ams.

Haj Omran, 2.-13.6.1956, weitere 6 Männchen, meist sehr schlecht erhalten, dieser nach einem Männchen aus Shaqlawa beschriebenen Art. Zur Nomenclatur und Systematik der Art ist zu sagen, dass der Gattungsname *Tortricomorpha* Amsel (1955) als Homonym von *Tortricomorpha* Felder (1861) wieder einzuziehen ist. Möglicherweise gehört die Art in die Gattung *Aphelia* Hb. oder *Clepsis* Gn., auf alle Fälle gehört sie zur Tribus *Archipsini*. Die endgültige Entscheidung dieses Problems wird demnächst Dr. OBRAZTSOV treffen, dem ich nach Auffindung weiterer Exemplare Material zuleiten kann.

Cnephasia nigripunctana, sp. n.

Spw. 21 mm. Thorax, Schultern und Kopf weisslich. Vfgl.-Grundfarbe und Fransen rein weiss, ohne Silberglanz. Mit etwa 35 feinen, kleinen, schwarzbraunen Pünktchen unregelmässig bestreut. Längs der Costa einige kaum auffallende gelbbraune Schuppen. Hfgl. und Hinterleib grau, Fransen der Hfgl. etwas heller grau. Palpen grauweisslich, kurz, die Stirn nur wenig überragend, Fühler schwach geringelt, pubescent.

Die schwarzbraunen Punkte des Vfgl. sind oft von heller bräunlichen Schuppen begleitet. Die rein weissen Fransen zeigen auch einige ganz wenige bräunliche Schuppen.

Genitalapparat des Männchens (Taf. IV, Fig. 1): Sacculus-Leiste bis 4/5 des Innenrandes reichend. Aedoeagus schmal. Socii ziemlich kurz, nur bis $^1/_3$ des Gnathos reichend, dessen letztes Viertel umgebogen ist.

Monotypus: 1 Männchen, Haj Omran, 2.-13.6.56.

Die Art gleicht äusserlich am meisten *virginana* Kennel und *albatana* Chrét., etztere ist aber mit 15-18 mm. Spw. wesentlich kleiner und nach der Costa zu sind die Vfgl. etwas bräunlich. *Virginana* hat weisse Hfgl. und auf den Vfgl. im costalen Teil den Anfang der Schrägbinde.

Cnephasia facetana Kenn.

Haj Omran 2.-7.6. (det. RAZOWSKI)

RAZOWSKI hält die beiden hierher gehörigen Stücke möglicherweise für eine Unterart der *facetana*. Die Art war bisher aus Palästina und Persien bekannt.

Lozopera sp.

Ein Weibchen von 16 mm. Spw. aus Hajji Omran, 30.7.1954 kann leider wegen des Fehlens des dazugehörigen Männchens nicht sicher bestimmt werden. Bisher war keine Art der Gattung aus dem Irak bekannt geworden.

Euxanthis subflavana, sp. n. (Taf. X, Fig. 6).

Spw. 21-23 mm. Vfgl.-Grundfarbe blass-gelblich. Kleine dunkle Costalhäkchen besonders im basalen Teil der Costa. Einzelne dunkelbraune Schuppen auf der ganzen Flügelfläche mit Ausnahme von Apex und Saum. Schwach perlmutterartig glänzende Schuppen überall. Hfgl. hellgrau, Fransen weisslich, Fühlerbewimperung 1.

Die Costalhäkchen sind nach dem Apex zu heller braun, sie stehen zur Wurzel hin dichter und hören vor dem Apex fast ganz auf. Fransen blassgelb, ohne Perlmutterglanz. Thorax blassgelb, Kopf noch heller. Palpen weissgelblich, mit einigen dunklen Schuppen. Flügelgeäder wie bei *kurdistana* Ams.

Genitalapparat des Männchens (Taf. IV, Fig. 3): Uncus abgerundet. Sacculus in eine kurze, breite Spitze bei 2/3 Innenrand der Valve ausmündend. Transtilla einspitzig. Aedoeagus ohne Cornuti. GU. 3374.

Holotypus: 1 Männchen, Hajji Omran, 26.7.1954.

Paratypus: 3 Männchen, Hajji Omran, 26.-31.7.1954.

Euxanthis kurdistana, sp. n. (Taf. X, Fig. 7).

Spw. 24-26 mm. Vfg.-Grundfarbe gelb, schwach perlmuttrig gewölkt. Hfgl. dunkelgrau. Fühlerbewimperung 1.

Die Art ist ohne jede Zeichnung, der perlmuttrige Glanz geht wie eine feine Rieselung über den ganzen Flügel. Fransen gelb, ohne Perlmutter. Hfgl.-Fransen hellgrau mit dunkelgrauer Basallinie. Thorax und Kopf gelb, hinterleib grau. Palpen hellgrau, innen und unten fast weiss. Unterseite der Vfgl. dunkelgrau, Fransen der Costa und des Saumes hell. Hfgl.-Fransen hellgrau, oberhalb der *sc* dunkler.

Genitalapparat des Männchens (Taf. IV, Fig. 2): Innenrand der Valve gleichmassig abgerundet, Uncus zweilappig, Transtilla einspitzig. Aedoeagus plump, basalwärts verdickt, ohne Cornuti. GU. 3373.

Holotypus: 1 Männchen, Hajji Omran 25.7.1954.

Paratypus: 5 Männchen, Hajji Omran, 31.7.1954.

* *Phalonia posterana* Z.

Haj Omran, 2.-13.6.1956.

Euxanthis straminea Hw.

Haj Omran, 2.-13.6.1956.

Lobesia (*Polychrosis*) *botrana* Schiff.
Bagdad, 21.5.1955.

Bactra lanceolana Hb.
Haj Omran, 2.-13.6.56 (GU. 3372).

* *Bactra graminivora* Meyr.
Bagdad, 18.5.1956 (GU. 3371), 6.5. und 8.10.1956.

Phiaris kurdistana, sp. n. (Taf. IX, Fig. 10).

Spw. 20 mm. Vfgl.-Grundfarbe olivgrün, Costa mit etwa 20 schwarzen Costalhäkchen, wenig auffallende Aufhellungen dazwischen. Unterbrochene Bleilinien in Querlinien über den ganzen Flügel verstreut. Eine Querbinde der Grundfarbe von $^2/_3$ Costa zum Tornus. Fransen etwas heller als die Grundfarbe. Hfgl. schwärzlich, Fransen hell, zum Innenwinkel hin dunkler.

Die Costalhäkchen stehen in ziemlich gleichen Abständen längs der ganzen Costa, nach dem Apex zu werden die Aufhellungen dazwischen etwas deutlicher. Ein abgegrenztes Wurzelfeld fehlt. Im Gebiet der Flügelwurzel fehlen die Bleilinien, stattdessen treten hier schwarze Quer-Rieselungen auf. Das querlinienfreie Band von $^2/_3$ Costa zum Innenwinkel ist über dem Innenwinkel eingeengt. Fransen an der Basis mit feiner dunklerer Schuppenreihe. Thorax und Schulterdecken wie die Flügelwurzel gezeichnet, ohne Bleilinien. Fühler oberseits olivfarben, unterseits dunkler, Bewimperung $^1/_2$. Palpen oliv-gelblich, heller als die Flügel, mit schwarzen Schuppen stark gemischt. Letztes Glied schwarz, nur an der Spitze heller. Beschuppung abstehend-struppig. Vfgl.- Unterseite dunkel, helle Costalhäkchen längs der ganzen Costa. Hfgl. etwas heller, nach der Costa und dem oberen Teil des Aussenrandes stark aufgehellt.

Genitalapparat des Männchens (Taf. IV, Fig. 4): Uncus vom Tegumen nicht abgetrennt, abgeflacht. Socii als kleine Lappen entwickelt, ohne Borsten oder Haare. Gnathos flach. Aedoeagus kurz, ziemlich dick, fast gerade, ohne Cornuti. Innenrand der Valve bei $^1/_2$ tief eingebuchtet, dahinter stark hervortretend und dieser Vorsprung mit einer grösseren oberen und einer kleineren unteren Reihe kräftiger Borsten.

Monotypus: 1 Männchen, Haj Omran, 2.-13.6.1956.

Die Art kann am besten bei *stibiana* Gn. eingeordnet werden.

Epiblema kurdistana, sp. n.

Spw. 12 mm. Vfgl. grau-braun mit 5 Paar hellen Doppel-Costalhäkchen. Am Innenrand bei $^1/_3$ ein heller, ziemlich breiter, ganz unbestimmter Fleck, der sich bis zur Zelle hinzieht. Spiegel fehlend. Hfgl. graubraun. Fühler pubescent. Kopfhaare dunkel und hell gemischt.

Aus dem letzten Doppelhäkchen vor der Spitze zieht eine helle, unbestimmte Linie am Saum entlang, die jedoch teilweise unterbrochen ist. Fransen wie die Flügelfläche, an der Basis leicht gescheckt. Im Hfgl. sind m^3 und cu^1 ganz kurz

gestielt. Auf der Vfgl.-Unterseite sind 3 Paar Doppelhäkchen deutlich, davor stehen ± deutlich an der Costa noch 1-2 helle Fleckchen. Costal-Umschlag ziemlich kurz.

Genitalapparat des Männchens (Taf. V, Fig. 1): Socii unbehaart. Cucullus gut abgesetzt. Costa nahe der Basis leicht vorgewölbt. Aedoeagus ohne Cornuti. GU. 3401.

Monotypus: 1 ziemlich schlecht erhaltenes Männchen, Haj Omran, 2.-13.6. 1956.

Laspeyresia coluteana, sp. n. (Taf. IX, Fig. 8).

Spw. 15 mm. Der Pammene juliana Curt. *ähnlich. Vfgl.-Grundfarbe elfenbeinfarben grauweisslich. Wurzelfeld bei $^1/_3$ des Innenrandes bis zur Falte begrenzt, dann zur Costa hin unbegrenzt. Sehr zahlreiche feine graue Costalhäkchen. Spiegel mit sehr breiten Bleilinien wurzelwärts und zwei weniger breiten Bleilinien auswärts. Schwarze Beschuppung beiderseits des Spiegels auf dunklerem Grunde, Saum überwiegend dunkel, Fransen dunkelgrau, glänzend. Hfgl. grau, wurzelwärts heller. Fransen grau mit Basallinie.*

Die Art gleicht *juliana* ausserordentlich, bei dieser ist aber das ganze Wurzelfeld bis zur Costa grau, während bei *coluteana* der über der Falte liegende Teil des Wurzelfeldes von der elfenbeinfarbenen Grundfarbe eingenommen wird. Die Costalhäkchen sind viel zahlreicher und feiner, nach dem Apex zu wird die Grundfarbe zwischen ihnen fast weiss. Der Spiegel ist auf der Innenseite viel dunkler angelegt. In dieser dunklen Fläche ist die Begrenzung zur Wurzel hin überwiegend von schwarzen, senkrecht verlaufenden Schuppen gebildet, ebenso sind direkt am Spiegel schwarze Schuppen. Die zwischen den beiden Bleilinien des Spiegels liegenden schwarzen Schuppen verlaufen waagerecht. Oberhalb des Spiegels führt eine Bleilinie zum 5. Costalhäkchen. Darüber steht noch eine kleine Bleilinie, die direkt zum Apex führt. Saum unterhalb des Apex etwas eingezogen. Fransen an ihrer Basis schwärzlich. Palpen hellgrau, letztes Glied sehr klein, grau. Fühler sehr kurz bewimpert, fast pubescent. Kopf grau.

Genitalapparat des Männchens (Taf. IV, Fig. 5): Aedoeagus am Ende tief gespalten. Cucullus durch eine tiefe Einbuchtung des Innenrandes der Valve deutlich abgestetzt. Uncus fehlend. Gnathos gut entwickelt. GU. 3369.

Monotypus: 1 Männchen, Salah-ud-Din, 3000 ft., Kurdistan. Raupe VI. 1956 in Schoten von *Colutea* gefunden, Falter ex 1.7.10.1956.

Anmerkung: ich stelle die Art zunächst zu *Laspeyresia* im Sinne von KENNEL. — da das Flügelgeäder dem entspricht, d.h. im Hfgl. entspringt *rr* frei, weit wurzelwärts von der oberen Zellgrenze, und der gemeinsame Stiel von cu^1 und m^3 — ist $^1/_3$ so lang wie die freien Äste. Die Art hat auch eine gewisse Ähnlichkeit mit *splendana* Hb. und kann zunächst bei dieser eingeordnet werden.

Laspeyresia sp.

Aus Shaqlawa, 6.8.1953, liegt ein Männchen von 15 mm. Spw. einer Art vor, die vorläufig unbestimmbar bleibt, weil das einzige vorhandene Stück voll-

ständig verölt und auch sonst sehr schlecht erhalten ist. Auch die Gattungszugehörigkeit bleibt unsicher, da das Geäder des Hfgl. nicht sicher zu erkennen ist, da beide Hfgl. sehr stark zerknittert sind. Erkennbar ist lediglich, dass die Palpen leicht aufgebogen und hell und dunkel meliert sind. Auch der Kopf ist so beschuppt.

Genitalapparat der Männchens (Taf. IV, Fig. 6): Innenrand der Valve vor dem Beginn des Cucullus mit einem feinen Dorn, Cucullus breit ausladend, sein Aussenrand mit einer Reihe feiner kurzer Borsten. Aedoeagus breit, nach vorne etwas verjüngt mit 4 kleinen Cornuti. GU. 3370.

Dichrorampha obraztsovi, sp. n.

Spw. 11,5 mm. Vfgl. auf grau-glänzender Grundfarbe mit feiner gelblicher Beschuppung, die zum Saum und Apex ganz fein streifig angeordnet ist, 5-6 Costalhäkchen, 3 schwarzen Saumpunkten und bleigrau glänzenden Fransen. Hfgl. Kopf, Palpen, Fühler grau.

Von den grauen Costalhäkchen vereinigen sich das letzte und vorletzte an ihren Enden unweit des Saumes. Zwischen den Costalhäkchen der Grundfarbe wirkt die Zeichnung zwischen den Häkchen wie weitere 6 Costalhäkchen. Von diesen zeigen das 1.-4. an ihren Enden einige schwarze Schuppen.

Genitalapparat des Männchens (Taf. V, Fig. 3): Ohne Anellus lobes. Aedoeagus sehr lang und ganz spitz auslaufend. Cucullus sehr deutlich abgesetzt. GU. 3402.

Monotypus: 1 Männchen, Haj Omran, 2.-13.6.1956.

Die neue Art gehört wegen des fehlenden Costalumschlages und des einfachen Anellus zur Untergattung *Lipoptychodes* Obr., wo sie der aus Armenien beschriebenen *inconspiqua* Danil. am nächsten stehen dürfte. Diese hat einen sehr ähnlichen Cucullus, aber einen ganz abweichenden Aedoeagus.

Ich widme die neue Art Herrn Dr. Obraztsov in herzlicher Freundschaft, der die so ungemein schwierige Gattung *Dichrorampha* in seiner kürzlich erschienenen Arbeit (*Mitt. Münch. Ent. Ges.*, XLIII, p. 10-101, 1953) in hervorragender Weise behandelte und damit erstmalig eine Grundlage für die weitere Arbeit in diesem Genus schuf.

* *Pammene juliana* Curt. (?)

Ein Weibchen aus Haj Omran, 2.-13.6.1956, ist leider so schlecht erhalten, dass die Bestimmung nicht ganz sicher ist. Da die Art im östlichen Mittelmeergebiet bis Rhodos nachgewiesen wurde, ist ihr Vorkommen in den höheren Gebirgsregionen Kurdistans durchaus möglich.

Glyphipterygidae

Klimeschia lutumella Ams.

Haj Omran, 2.-13.6.1956, zwei schlecht erhaltene Männchen, bei denen der Innenrandsfleck kaum entwickelt ist.

Simaethis sp.

Ein Weibchen von 15 mm. Spw. aus Rowanduz Gorge, 2000 ft, 14.6.1956, ist leider auf den Vfgl. völlig abgerieben, auf den dunklen Hfgl. zeigt es von cu^1 bis fast zur Analis einen weissen, kurzen Querbalken, der auf der Flügelunterseite bis zur Costa geht und hier noch einen Seitenast bis fast zur Subcosta entsendet. Weisse Schuppen sind auch hier reichlich im Gebiet des Saumes. Auf der Vfgl.-Unterseite ist an der Costa bei 3/4 -4/5 ein ziemlich grosser weisser Fleck und ein ebensolcher zwischen m^2 und cu^2. Es handelt sich wahrscheinlich um eine noch unbeschriebene Art.

Glyphipteryx bifasciella, n.sp. (Taf. IX, Fig. 6).

Spw. 11 mm. Vfgl. mit zwei silbrig-glänzenden Querbinden hinter der Flügelmitte, drei weissen Costalhäkchen vor dem Apex, einem schwarzen, nicht silbern gekernten Augenfleck am Apex, drei schwarzen, nebeneinander liegenden Flecken am Saum. Fransen über dem Augenfleck ohne dunkles Schwänzchen.

Die erste Querbinde geht von der Mitte der Costa in deutlichem Bogen nach aussen zur Mitte des Innenrandes. Dahinter verläuft, weniger stark gebogen, die zweite Linie. Sie beginnt mit einem weissen Costalhäkchen, das sehr bald vom Silber der Binde abgelöst wird. Die erste Binde ist an der Costa unmerklich schmaler als am Innenrand, die zweite im ganzen Verlauf gleich breit. Dahinter folgen die drei weissen Costalhäkchen, von denen das dritte in eine silberne Linie übergeht, die den schwarzen Augenfleck umschliesst und bis zum Aussenrand continuierlich durchgeht. Die drei schwarzen Saumflecke liegen unmittelbar unterhalb der stark vortretenden Flügelspitze.

Monotypus: 1 schlecht erhaltenes Weibchen, Haj Omran, 2.-13.6.1956.

Die Art dürfte der aus Rhodos beschriebenen *medianella* Trti. (*Mem. Soc. Ent. Ital.*, IX, p. 211, 1930) am nächsten stehen, die aber mit 9 mm kleiner bleibt.

Gelechiidae

Pterolonche kurdistanella, sp. n.

Spw. 26 mm. Vfgl.-Grundfarbe weisslich, Adern sehr schwach dunkel angelegt, keine dunklen Schuppen zwischen den Adern.

Die Art steht äusserlich *albescens* Z. am nächsten, doch hat diese stark dunkel angelegte Adern.

Im Genital (Taf. V, Fig. 4) sind beide Arten sehr verschieden, indem bei *albescens* der Gnathos bis zum Uncus-Ende reicht und das Dornenpaar an der Basis des Uncus länger und zugleich dünner ist. Das Tegumendach ist bei *kurdistanella* nach dem Uncus zu auch stark gewölbt. Im Genital vielleicht ähnlicher ist *vallettae* Ams. (*Bull. Inst. Sci. nat. Belg.*, XXXI, Nr. 83, p. 24, Taf. 3, Fig. 6, 1955), doch hat *kurdistanella* einen noch etwas kürzeren Gnathos der nur bis 1/2 der Uncus-Länge reicht und das Tegumendach ist stärker gebuckelt. Das Dornenpaar ist etwas

länger und kräftiger. Äusserlich ist *vallettae* etwas kleiner und breitflügliger und durch die dicht graue Beschuppung zwischen den Adern viel dunkler.

Monotypus : 1 Mäunchen Shaqlawa, 20.9.1953 (GU. 3378).

Eremica (Symmoca) kalifella Ams.

Bisher waren nur Männchen bekannt, sodass ergänzend zur Original-Beschreibung gesagt werden muss: Weibchen mit kürzeren, hängenden oder schwach vorgestreckten hellgrauen Palpen. Fühler dünner, *rr* und m^1 der Hfgl. noch länger gestielt, erst unmittelbar vor dem Saum gabelt sich die Ader.

Allotypus: 1 Weibchen, Bagdad, 11.5.1956.

Paratypus: 1 Weibchen, Bagdad, 11.5.1956.

Asbolistis chthoniopa Meyr.

Hajji Omran 31.7.1954, ein Männchen von 18 mm Spw.

Das Stück passt gut zu der Beschreibung, die GOZMANY von *Exorgana iranica* Gozm. (*Ann. Hist. Nat. Mus. Nat. Hung.*, VIII, p. 345, Fig. 9G, 1957) gegeben hat, so dass an der Identität beider Arten nicht gezweifelt werden kann und sowohl die Gattung *Exorgana* als Synonym von *Asbolistis* Meyr. 1936 (Exot. Micr. 5, p. 48) wie auch *iranica* Gozm. als Synonym von *chthoniopa* Meyr. 1936 (l.c., p. 49) wieder einzuziehen sind. Das WILTSHIRE'sche Stück weicht jedoch in einigen Kleinigkeiten von der Beschreibung bei GOSMANY ab. So ist die Costa ganz fein gelb angelegt, was auch auf der Unterseite deutlich ist. Davon schreibt GOZMANY nichts. Im Genitalapparat fällt auf, dass der Innenrand der Valve bei dem kurdistanischen Stück ganz gleichmässig wie ein Viertelkreis gebogen ist, während bei der Abbildung von *iranica* hier ein deutlicher überstumpfer Winkel bei $^1/_3$ des Innenrandes auftritt. Auch ist der Uncus bei *iranica* plumper, die Spitze kürzer. Die Bildung des Aedoeagus-Anellus-Komplexes kommt auf der Abbildung der *iranica* nicht zur Geltung, da hier eine Lateral-Ansicht vorgeführt wird. Ich gebe daher auf alle Fälle noch eine Ventral-Ansicht, die die bemerkenswerten Einzelheiten gerade dieses Teiles der Armatur deutlich macht (Taf. V, Fig.7) GU. 3384, obwohl in meiner Arbeit in Bd. 33, 1949, dieser Zeitschrift auf Tafel 10 unter Fig. 66 die Art bereits abgebildet wurde. Zum Vergleich mit der sehr ähnlichen, genitaliter aber stark abweichenden *funebrella* Chrétien (= *umbrinella* Zerny) aus Marocco sei auch der Genitalapparat dieser Art in Ventral-Ansicht wiedergegeben. GU. 3383.

Zum Geäder der beiden Arten ist zu sagen:

chthoniopa: Vfg. cu^1 und cu^2 sind ganz kurz gestielt. Hfgl. *rr* und m^1 kürzer gestielt als bei *funebrella*, der gemeinsame Ast von der oberen Zellgrenze entspringend, die hier nicht rückgebildet ist ! cu^1 und m^3 aus einem Punkt von der unteren Zellecke. Zwischen diesem und der Abgangsstelle von *rr* und m^1 genau in der Mitte entspringt m^2.

funebrella: r^4 und r^5 lang gestielt, die Spitze umgreifend, der gemeinsame Stiel ist etwas länger als die freien Äste, m^1 bis cu^1 in ziemlich gleichen Abständen,

cu^2 nahe bei cu^1. Hfgl: *rr* und m^1 lang gestielt, der gemeinsame Stiel kommt nicht aus der Zelle, sondern hört wurzelwärts auf, da die obere Zellgrenze nicht entwickelt ist. m^2 von der oberen Zellecke, m^3 und cu^1 von der unteren Zellecke, ganz kurz gestielt.

Symmoca fuscella, sp. n. (Taf. X, Fig. 13).

Spw. 13 mm. Thorax- und Vfgl.-Grundfarbe hellbraun, dunkelbraun gemischt, Kopfhaare mehr grau. Fühler bis $^4/_5$ der Costa reichend, ziemlich dick, braun, ganz schwach hellbraun geringelt, nackt. Zweites Palpenglied aussen braun, nur am Ende hellgrau, innen hellgrau, drittes Glied so lang wie das zweite, allseitig grau.

Die dunkelbraunen Schuppen sind ziemlich diffus über die ganze Flügelfläche verteilt, sie führen zu einer Schattenbildung bei 3/4 Costa und am Innenwinkel. Fransen braun, mit einigen dunkleren Schuppen gemischt. Hfgl. gleichmässig braun. Im Vfgl. sind r^4 und r^5 gestielt, der gemeinsame Stiel ist nur wenig länger als die freien Äste, cu^1 und cu^2 kommen aus einem Punkt. Hfgl: *rr* und m^1 sind kurz gestielt, m^3 und cu^1 kommen aus einem Punkt.

Genitalapparat des Männchens (Taf. VI, Fig. 5): Sacculus ziemlich kurz und dick, fingerförmig, nicht bis zur Costa reichend. Anellus aus einem grösseren fingerförmigen und einem kleinen Vorsprung bestehend. GU. 3382.

Monotypus: 1 Männchen, Rayat, 5000 ft., 30.7.1954.

Pleurota idalia Meyr.

Haj Omran, 2.-13.6.1956. Gora Shala, 1.4.56. Eine sehr variable Art.

Pleurota irakella, sp. n. (Taf. X, Fig. 11).

Spw. 15 mm. Kopf, Thorax, Schulterdecken, Vfgl. einschliesslich Fransen einfarbig hell-lehmfarben, glanzlos. Hfgl. grau, Fransen grau-lehmfarben.

Vfgl.-Unterseite dunkelgrau, Fransen heller gelbgrau, Hfgl.-Unterseite hellgrau, Fransen gelbgrau. Palpenendglied wenig abgewinkelt, nur unbedeutend über die Schuppen des zweiten Gliedes hinausragend. Fühler oberseits mit lehmfarbenen Schuppen, Bewimperung etwas über 1. cu^1 und cu^2 im Vfgl. ganz kurz gestielt, im Hfgl. m^3 und cu^1 fast aus einem Punkt.

Genitalapparat des Männchens (Taf. VI, Fig. 1) : Valven ziemlich schmal Apex lang abgerundet. Gnathos mit scharfer Spitze, unterer Rand bei Lateral-Ansicht fast gerade. Uncus klein, sehr spitz ausmündend. Aedoeagus nach dem Ende zu nur schwach sich verjüngend, ziemlich lang. Anellus-Arme über das Aedoeagus-Ende deutlich hinausragend. GU. 3381.

Holotypus : 1 Männchen, Haj Omran, 2.-13.6.1956.

Paratypus : 5 Männchen, Haj Omran, 2.-13.6.1956.

Pleurota semiticella, sp. n. (Taf. X Fig. 10).

Spw. 14-15 mm. *Kopf, Thorax, Schulterdecken, Vfgl. und Fransen einfarbig hellgrau-lehmfarben, glanzlos. Hfgl. dunkelgrau, Fransen nur wenig heller.*

Vfgl.- Unterseite dunkelgrau-bräunlich, Fransen gelbgrau. Hfgl.-Unterseite hellgrau, Fransen grau-gelblich. Palpenendglied im Schuppenbusch des zweiten Gliedes fast ganz versteckt, nicht abgewinkelt. Schuppenbusch oberseits überwiegend hellgrau, seitlich und unten überwiegend dunkelgrau. Fühler oberseits hell beschuppt, Bewimperung 1.

Im Vfgl. ist cu^1 etwas näher an m^3 als an cu^2, im Hfgl. kommen cu^1 und m^3 aus einem Punkt.

Genitalapparat des Männchens (Taf. VI, Fig. 2): Gnathos mit sehr scharfer, feiner Spitze. Valven breit und kurz, Apex mit scharfer Spitze, darunter eine weitere spitze Ecke. Aedoeagus ziemlich lang, letztes Drittel sehr dünn. Anellus-Arme kurz, nur bis 2/3 des Aedoeagus reichend. GU. 3380.

Holotypus : 1 Männchen, Djerrasch, Transjordanien, 7.4.1930, leg. H.G. Amsel.

Paratypus : 2 Männchen, Djerrasch, Transjordanien, 7.4.1930, leg. H.G. Amsel.

Die Art steht *indecorella* Rbl. am nächsten, für die die Stücke auch bisher gehalten wurden und demgemäss in meiner Arbeit "Weitere Mitteilungen über palästinensische Lepidopteren" (*Veröff. Kolon. Mus. Bremen*, I, p. 266, 1935) unter diesem Namen aufgeführt wurden. *Indecorella* hat aber unterseits weisse Hfgl. und die Vfgl. sind oberseits gelblichweiss. Die neue Art sieht äusserlich der *irakella* sehr ähnlich, ist aber genitaliter und im Vfgl.-Geäder deutlich abweichend. Im Zusammenhang mit der Beschreibung der *irakella* wurde festgestellt, dass die für *indecorella* gehaltenen Stücke tatsächlich nicht zu dieser, sondern zu einer noch unbeschriebenen Art gehören und daher an dieser Stelle mit beschrieben werden sollen.

Pleurotopsis pygmaeella, sp. n.

Spw. 11 mm, kleiner als *jordanella* Ams., die 11-15 mm gross ist, Fühler dunkler, fast schwarz, ungeringelt, Bewimperung 1,5. Drittes Palpenglied relativ gross, 1/2 so lang wie das zweite, stark abgewinkelt gegenüber dem zweiten Glied. Vfgl. fast zeichnungslos gelbgrau, Zellschlusspunkt unbedeutend, einige braungraue Schuppen können eingemischt sein.

Genitalapparat des Männchens (Taf. VI, Fig. 3): Gnathos fast ganz gerade, nicht gebogen wie bei *jordanella*. Aedoeagus schmaler, Innenrand der Valve ganz gerade. GU. 3379.

Holotypus : 1 Männchen, Jebel Darawishka, 19.2.1955.

Paratypus : 1 Männchen, Jebel Darawishka, 19.2.1955.

Bagdadia irakella Ams.

Gora Skala, 800 ft, 1.4.1956.

Metzneria sp. (Taf. V, Fig. 5).

Haj Omran, 2.-13.6.1956, vier Männchen von 14-16 mm, ein Weibchen von 18 mm haben auf hellgelblicher Grundfarbe rostfarbene und bleigraue Schuppen stark gemischt. Der Innenrand ist überwiegend grau, die Falte rostfarben, die sonstige Mischung beider Farbtöne schwankt stark. Saum meist grau. Fransen ebenfalls ± grau.

Genitalapparat des Männchens (Taf. V. Fig. 5) ; Innenrand der Valve nicht ganz gerade, Valvula abgerundet, Aedoeagus dünner, mehr gebogen, 4 Cornuti, die hintereinander liegen. GU. 3339.

Metzneria sp.

Haj Omran, 2.-13.6.1956, zwei Männchen, zwei Weibchen einer Art von 15-18 mm. Spw. können bei dem derzeitigen Chaos in der Gattung *Metzneria* noch nicht namentlich aufgeführt werden. Die Art hat auf schwach gelblichem Grunde der Vfgl. eine ± rostbräunliche Färbung, die besonders längs den Adern, in der Zelle, am Saum und Innenrand deutlich entwickelt ist. Die Costa, besonders deren Mitte, bleibt immer gelblich. Graue odersonstwie andersgefärbte Töne fehlen durchaus, ebenso Punkte. Palpen an den Seiten rostbräunlich, unterseits gelblich. Hfgl.grau.

Genitalapparat des Männchens (Taf. V, Fig. 6): Uncus gerade begrenzt, Valve mit ganz geradem Innenrand, Verbreiterung nach aussen nur schwach, Valvula mit fast spitzem Zipfel. Aedoeagus breit, Vesica mit einer Reihe von 4 Cornuti. GU. 3398.

Neofaculta confidella Rbl.

Rayat, 5000 ft., 30.7.1954, ein Männchen von 13 mm Spw. ist leider stark geflogen, doch ist die Art dank der sehr charakteristisch gebauten männlichen Genitalien gut wieder zu erkennen (det. SATTLER). Der Falter ist bräunlich, ein dunkler Fleck in der Falte bei 1/2, ein weiterer genau darüber in der Zelle und am Zellende. Apikaler Teil des Flügels dunkler beschuppt. Hfgl. grau-braun. Die Endglieder der Palpen fehlen, ebenso die Fühler bis auf wenige Basalglieder. Im Vfgl. sind r^{4+5} gestielt, r^5 geht vor der Spitze in die Costa, m^2 und m^3 dicht beieinander, cu^1 in der Mitte zwischen m^3 und cu^2 Hfgl: *rr* und m^1 kurz gestielt, m^3 und cu^1 aus einem Punkt.

Genitalapparat des Männchens (Taf. VI, Fig. 4): Uncus länglich, Valven bis zur Wurzel gespalten, daher zweiteilig. Beide Teile gleich lang, in der Gestalt etwas voneinander abweichend. Anellus aus einem Paar länglicher Arme bestehend. Aedoeagus dick, plump, am terminalen Ende mit einem Paar unsymmetrischer Klammerorgane, die den Aedoeagus ziemlich fest im abgerundeten Vinculum festhalten. Am Ende noch ein schraubenzieherartiges Gebilde, das vielleicht als Cornutus zu deuten ist. GU. 3385. Die Art war bisher aus Mardin bekannt.

* *Aristotelia euprepella* Zerny.

Ein mit der Originalbeschreibung ausgezeichnet übereinstimmendes Männchen aus Haj Omran, 2.-13.6.1956. Die Art war bisher vom Libanon und aus Marasch bekannt.

Anacampsis [Tachyptilia] malella, sp. n. (Taf. IX, Fig. 7).

Spw. 14-15 mm. Der *subsequella* Hb. äusserst ähnlich, etwas grösser, die dunklen Punkte auf der Falte, in der Mitte und am Zellende deutlicher, die Ver-

dunkelung vor der Querbinde schmaler, wodurch der Zellfleck isoliert erscheint. während er bei *subsequella* in die Verdunkelung einbezogen ist und daher so gut wie unsichtbar bleibt. Die Costa von der Mitte bis zur Querbinde ganz fein aufgehellt, besonders auch auf der Unterseite, die bei *subsequella* ganz einfarbig dunkel ist und nur ganz schwach in den Fransen den oberen hellen Fleck der Querbinde erkennen lässt. Dieser Fleck fehlt bei *malella*, weil die Costa in ganzer Länge aufgehellt ist. Sehr ähnlich ist auch *karmeliella* Ams., die die gleiche Grösse besitzt, aber ohne Punkte auf den Vfgl., ohne aufgehellte Costa und mit deutlichem hellen Fleck in den Fransen auf der Unterseite der Costa. *Karmeliella* ist in der Grundfarbe auch mehr braunschwarz, während *malella* grauschwarz ist.

Genitalapparat des Männchens (Taf. VI, Fig. 6): Dem von *subsequella* sehr ähnlich. Aedoeagus grösser, stärker gebogen, basale Verdickung erheblich grösser, Verlauf der inneren Röhre abweichend. Sacculusspitze stärker vorgezogen. Valven genau bis zum Uncus-Ende reichend, darin mit *subsequella* durchaus übereinstimmend, während bei *karmeliella* die Valven deutlich über den Uncus hinausragen und noch schmaler sind. GU. 3377.

Holotypus : 1 Männchen Bagdad. ex. l., *Pyrus malus*, 6.5.1956.

Allotypus : 1 Weibchen, ex l., *Pyrus malus*, 6.5.1956.

Anmerkung: *subsequella* lebt an *Prunus spinosa*, *karmeliella* an *Crataegus*. Die Auffindung einer an *Pyrus malus* lebenden Art schliesst damit den Ring der an Rosaceen lebenden Arten des Genus.

Metanarsia modesta kurdistanella, ssp. n. (Taf. X, Fig. 12).

Gegenüber der Nominatform aus Sarepta durch eine leichte, ± bandartige Verdunkelung des Saumes ausgezeichnet. Spw. 13-20 mm, in der Grösse also genau so stark variierend wie die Nominatform.

Holotypus: 1 Männchen, Haj Omran, 2.-13.6.1956.

Allotypus: 1 Weibchen, Haj Omran, 2.-13.6.1956.

Paratypus: 4 Männchen und Weibchen, Haj Omran, 2.-13.6.1956 und 31-7.1954.

Im Genitalapparat (Taf. VII, Fig. 5) des Männchen fand ich keinen besonderen Unterschied gegenüber einem Stück aus Uralsk. Die Valven sind bei dem untersuchten Stück aus Hajji Omran etwas schmaler und länger, die Valvula ist eine Kleinigkeit anders geformt, doch kann man darin keine arttrennenden Unterschiede sehen. GU. 3376. Die Art ist neu für die Fauna des Irak, ihr Vorkommen war zu erwarten, da sie aus Ak Chehir, der Silberküste in Rumänien, Sarepta, Indersky, Krasnojarsk, vom Embafluss, aus Buchara und dem Gouvernement Kasan bakannt war.

Onebala lamprostoma Z.

Bagdad, 7.10.

Nothris verbascella clarella Ams.

Haj Omran, 2.-13.6.1956.

Plutellidae

Plutella maculipennis Curt.

Gora Ghala, 29.3., Haj Omran, 2.-13.6.1956.

Ethmiidae

* *Ethmia amasina* Stgr.

Haj Omran, 2.-13.6.1956. Die Zahl der Saumpunkte schwankt bei dieser Art ziemlich stark.

Ethmia caradjae Rbl.

Haj Omran, 2.-13.6.1956, ziemlich häufig.

Ethmia kurdistanella, sp. n. (Taf. X, Fig. 8).

Spw. Männchen 21 mm, Weibchen 18 mm. Fühlerbewimperung des Männchens 1. Der *infelix* Meyr. (=*confusella* Rbl.) so nahe stehend, dass die Angaben der unterscheidenden Merkmale genügen: etwas grösser, Vfgl. etwas gestreckter. Fühler viel länger bewimpert. Innenrand mehr elfenbeinfarbig, ebenso Thorax, Tegulae, Kopf nicht weisslich. Saumpunkte viel deutlicher und bis zum apikalen Teil der Costa gehend, insgesamt 8-9 Punkte gegenüber 4-5 bei *infelix*, dabei dieser auch nur auf dem weissen Grunde des Saumteiles sichtbar sind. Verlauf des hellen Innenrandsteiles im Prinzip wie bei *infelix*, aber ohne den Vorsprung dieses hellen Teiles direkt am Saum. Der Saum ist also bis fast zum Innenwinkel gleichmässig dunkel (im Bereich der Saumpunkte allerdings leicht aufgehellt, so dass diese sich gut abheben !), während bei *infelix* der Saum nur zum Apex hin dunkel ist, in der unteren Hälfte dagegen weisslich. Hfgl. und Fransen grau, letztere basal etwas aufgehellt. Hinterleib einfarbig grau, seidig glänzend.

Genitalapparat des Männchens (Taf. VII, Fig. 1) : Überraschend stark abweichend von *infelix*. Uncus abgerundet, nicht zweigeteilt, auffallend schwach chitinisiert. Gnathos sehr breit, schaufel-förmig, fast so breit wie das Tegumen. Eine darunter befindliche breite Platte, deren oberer Rand ausgehöhlt ist, an allen Rändern mit einem Kranz von Dornen. Valven viel weniger breit, in eine scharfe Spitze ausmündend. GU. 3356.

Holotypus: 1 Männchen, Haj Omran, 2.-13.6.1956.

Allotypus: 1 Weibchen, Haj Omran, 2.-13.6.1956.

Paratypus: 1 Weibchen, Haj Omran, 2.-13.6.1956.

Ethmia (?) rayatella, sp. n. (Taf. IX, Fig. 9).

Spw. 23 mm. Vfgl. einfarbig dunkelgrau (etwas dunkler als bei Hyponomeuta vigintipunctata Retz.), *leicht glänzend, mit einem schwarzen Punkt in der Falte bei 1/2, einem weiteren in der Zelle und einem dritten am Zellende. Hfgl. grau. Abdomen in ganzer Länge dunkel, nur das letzte Segment gelblich. Kopfhaare rostfarben, Palpen grau. Fühlerbewimperung 1/5, r^1 im Vfgl. sehr weit wurzelwärts bei 1/3 der oberen Zellgrenze.*

Der Punkt in der Zelle steht genau in der Mitte zwischen Zellschluss- und Faltenpunkt. Palpen vorgestreckt, anliegend beschuppt, letztes Glied 2/3 so lang wie das zweite. Palpus in ganze Länge grau, nur innen ist das zweite Glied überwiegend hell.

Genitalapparat des Männchens (Taf. VII, Fig. 2): Uncus fehlend, Gnathos klein, aber breit, Valven breit und kurz, Costa der Basis wie ein kleiner Finger vortretend, Costa-Aussenteil als längerer Finger. Aussenrand mit feiner Spitze Aedoeagus gebogen, kurz, ohne Cornuti. GU. 3357.

Monotypus: 1 Männchen, Haj Omran, 2.-13.6.1956.

Der fehlende Uncus und die sehr weit wurzelwärts entspringende r^1 der Vfgl. machen es wahrscheinlich, dass für diese Art ein eigenes Genus errichtet werden muss. Sie kann nur vorläufig bei *Ethmia* untergebracht werden.

Momphidae

* *Cosmoptery flavofasciata* Woll.
Bagdad, 13.7.1956.

Batrachedra amydraula Meyr.
Bagdad, 17.5., 1.6.

* *Stagmatophora fulguritella* Rag.
Hajji Omran, 29.7.1954.

TENUIPENNA, n. gen.

Kopf anliegend beschuppt, Rüssel normal, Palpen anliegend, glatt beschuppt, aufgebogen, drittes Glied so lang wie das zweite. Vfgl.- und Hfgl. sehr schmal, Hfgl. mit sehr langen Fransen. Vfgl.-Geäder: $r^{4\ 5}$ lang gestielt, die Spitze umgreifend. m^1 ganz kurz mit r^{4+5} gestielt, m^2 und m^3 zu einer Ader zusammenfallend, cu^1 in der Mitte zwischen cu^2 und m^{2+3}. Hfgl.-Geäder: rr in die Spitze, m^1, m^2, m^3 in ziemlich gleichen Abständen, cu^1 und cu^2 etwas weiter entfernt. Costa bei 1/5 mit kleinem Borstenbesatz.

Genitalapparat des Männchens: Uncus unsymmetrisch, aus einem grossen und einem kleinen Haken bestehend. Valven lanzettlich mit isolierter, behaarter, lanzettlicher Valvula. Gnathos fehlend.

Typus: *Tenuipenna simplicella* sp. n.

Die neue Gattung kann zunächst bei *Batrachedropsis* Ams. (Typus: *ledereriella* Z.) untergebracht werden, wo auch ein unsymmetrischer Uncus vorhanden ist. Doch hat *Batrachedropsis* noch viel schmalere Hfgl. mit ganz reduziertem Geäder (Vergl: Amsel, *Bull. Inst. roy. Sci. nat. Belg.*, XXXI, Nr. 83, p. 15, Taf. II, Fig. 1-3, 1955).

Tenuipenna simplicella, sp. n. (Taf. X, Fig. 14).

Spw. 7-8 mm. Vfgl. zeichnungslos grau-bräunlich, am äussersten Apex dunkelbraune Schuppen. Hfgl. hellgrau. Fransen 5-6 mal so lang wie der Flügel breit. Fühler

sehr dünn bewimpert, Länge der Wimpern 1. Fühler hellbraun, mit etwas abstehenden Schuppen besonders zum Ende hin. Basalglied mit einigen längeren Borsten. Palpen kräftig aufgebogen, zweites Glied am Ende etwas dunkler, letztes so lang wie das zweite, etwas heller.

Genitalapparat des Männchens (Taf. VII, Fig. 3): Rechter Uncushaken mindestens doppelt so lang und kräftig wie der linke. Tegumen sehr schwach chitinisiert. Valven so lang wie die Valvulae, letztere ebenso lanzettlich wie die ersteren, auf der Innenseite lang behaart. Aedoeagus gerade, kräftig, nach vorne etwas verjüngt, ohne Cornuti. GU. 3403, 3404.

Holotypus: 1 Männchen, Bagdad, 13.5.1956.

Paratypus: 4 Männchen, Bagdad, 16.5., 15.6., 12.8. Alle Exemplare schlecht erhalten und stark geflogen.

* *Ascalenia eremella* Ams.

Bagdad, 6.5. und 1.8.1956. Die Art war bisher nur aus Palästina bekannt.

Scythrididae

* *Scythris monochroella* Rag.

Bagdad, 12.5., 11.8., zwei Weibchen. Die Weibchen sind gegenüber den Männchen an dem bräunlichen 4.-5. Segment des Abdomens kenntlich.

* *Scythris unipunctella* Rbl.

Haj Omran, 2.-13.6.1956, 2 Männchen, 2 Weibchen (det. HANNEMANN). Bisherige Verbreitung: Eibes (Taurus-Gebirge), Marasch, Erivan, Wan. Kuldscha.

Ooecophoridae

* *Borkhausenia icterinella* Mn.

Shaqlawa, 4.7.1953.

* *Agonopteryx funebrella* Car.

Haj Omran, 2.-13.6.1956, ein Männchen (det. HANNEMANN).

Die Art war bisher nur aus Uralsk bekannt.

Agonopteryx aspersella Const.

Shaqlawa 29.8.1935.

Die Art ist identisch mit *Depressaria autocnista* Meyr. 1921, von der HANNEMANN der weibliche Typus vorlag.

Der MEYRICK'sche Name ist also wieder einzuziehen.

* *Depressaria campestrella* Chrétien

Haj Omran, 2.-13.6. 1956, drei Männchen.

Die Art war bisher nur aus den Pyrenäen bekannt (det. HANNEMANN).

Bucculatricidae

* *Bucculatrix albella* Stt.

Bagdad, 6.5.1956, ein Exemplar, das mit palästinensischen Stücken sehr gut übereinstimmt. Zwei weitere Exemplare vom 6. und 11.5. sind so stark geflogen, dass ihre Bestimmung unsicher bleibt. Die Art war bisher nur aus Palästina bekannt.

Coleophoridae

* *Coleophora wiltshirei* Toll.

Hajji Omran, 25.7.1954.

Monotypus Männchen GU. 3264 (Präparat Nr. 32 Toll).

* *Coleophora chamaedryella* Stt.

Mosul, 16.5., ein Männchen GU. 3277 (det. Toll).

Gracilariidae

* *Lithocolletis turanica* Gerasm. (Taf. 10 Fig. 15).

Aus Minen an *Pyrus malus* gezogen Bagdad, 1.3., 2.3. und 20.3., zwei Männchen, ein Weibchen. Hering führt in seinen "Bestimmungstabellen der Blattminen von Europa" (1957) diese Art als Unterart von *corylifoliella* Hb. auf. Sie ist dieser in der Tat auch sehr ähnlich, aber schon durch die helleren Kopfhaare, die weiss und nur mit wenigen bräunlichen Schuppen untermischt sind, leicht zu trennen. Im Genitalapparat (Taf. VII, Fig 4) fehlt der Dorn am Apex der Valve und das 8. Sternit ist weniger breit. GU. 3400. Bis zur endgültigen Klärung der Frage, ob wir es hier nur mit einer Unterart oder doch mit einer bona species zu tun haben, wird es sich empfehlen, sie als gute Art zu führen. Wiltshire führt in seiner Iraq-Fauna die Art unter Nr. 874a auf. *Turanica* ist in der Intensität der schwarzen Beschuppung ziemlich variabel. Mir liegen Stücke vor, bei denen die Wurzelstrieme ohne jede schwarze Beschuppung der Ränder ist und solche, die ziemlich stark schwarz gerändert sind. Für das Costal- und Innenrandshäkchen gilt ähnliches.

* *Acrocercops eximipalpella* Grsm.

Bagdad, 1. und 11.6.1954, 29.7.

Tineidae

Bearbeitet von Dr. G. Petersen,

(*Deutsches Entomologisches Institut, Berlin- Friedrichshagen*).

Obgleich es sich nur um 13 Exemplare handelt, erwiesen sich bei näherer Untersuchung dieser Tiere 12 als neu.

Catabola cornuta, sp. n.

1 Männchen Typus, 5 Männchen Paratypen, Haj Omran Rayat, Iraq; VI. 1953. 1 Männchen Paratypus, Shaqlawa, Kurdistan, Iraq, VI. 1953,

Die neue Art ähnelt mit ihren langen, dicken Fühlern und ihrer Flügelfärbung am meisten *Catabola biskraella* Rbl., die bisher von Algier und Palästina bekannt ist, wobei die palästinensischen Exemplare etwas dunklere Vorderflügel aufweisen. Die Typenserie von *C. cornuta* ist in dieser Hinsicht auch nicht einheitlich, besonders das Exemplar von Shaqlawa ist heller, wenn auch die Färbung ganz allgemein vom Erhaltungszustand der Flügelbeschuppung abhängig ist.

Die männlichen Genitalien (Taf. VIII, Fig. 1) sind nach dem gleichen Prinzip gebaut, wie die von *C. biskraella* Rbl. In der Form des Uncus und der Valven bestehen nur sehr geringfügige Unterschiede. Zur sicheren Unterscheidung der beiden Arten dient am besten der Aedoeagus. Er ist kurz und kräftig, endet mit einem stark chitinisierten Horn, an dessen Stirnseite die Mündung liegt, während das dorsale Horn bei *C. biskraella* von der Mündung deutlich getrennt ist. *C. aegyptiella* Rbl. besitzt dagegen ein schlankes, leicht gebogenes Mündungsrohr (s. PETERSEN. *Beitr. Ent.*, VII, 565, Fig. 212, 213, 1957).

Wie bei allen bisher bekanntgewordenen Arten der Gattung ist auch von dieser neuen Art das weibliche Geschlecht unbekannt, obgleich keinerlei Anlass zu der Vermutung besteht, die Weibchen der *Catabola*-Arten seien ungeflügelt oder hätten verkümmerte Flügel.

Niditinea fuscipunctella (Hw. 1828).

Bagdad, 10.3, 8.4, 16.5., 16.12.

Es handelt sich bei dem Stück vom 16.5 um ein schlecht erhaltenes, auffällig kleines Exemplar dieser kosmopolitischen Art, das auch im Genitalapparat etwas von den mittel- und südeuropäischen Tieren, die bisher untersucht wurden, abweicht. Erfahrungen mit kosmopolitischen Tineiden haben jedoch gezeigt, dass man auch hinsichtlich Grösse, Färbung und Genitalarmatur der Männchen mit beträchtlichen Unterschieden rechnen muss, die zu Neubeschreibungen keinesfalls berechtigen.

Die Variabilität im männlichen Genitalapparat, soweit sie nicht schon durch Schwierigkeiten bei der Präparation bedingt ist (Valven !), betrifft vor allem die Form des Saccus und Aedoeagus, sowie dessen zwei Zähne, von denen aber auch europäischen Exemplaren einer fehlen kann, weshalb besonders auf diese Möglichkeit aufmerksam gemacht werden soll.

Paratinea striaticostella, sp. n. (Taf. IX, Fig. 1).

1 Männchen Holotypus, Bagdad, 5.X.1956.

Ein ziemlich gut erhaltenes Männchen, Spannweite 9-10 mm, lässt sich äusserlich gut charakterisieren. Die Vfl. am Costalrand etwa von der Mitte an mit mehreren deutlichen dunkelbraunen Strichen und einem ebenso gefärbten Fleck vor der Flügelspitze. Hfgl. schmal und scharf zugespitzt, mit langen Fransen. Stirnschopf grauweiss.

Die Genitalien (Taf. VIII., Fig. 2) verweisen diese Art eindeutig in die Nähe von *Paratinea merdella* Zll., zu der äusserlich keine näheren Beziehungen in der Färbung und dem Zeichnungsmuster zu erkennen sind. Uncus schnabelförmig,

distal ganz schwach gespalten Gnathos mit breiter Basis am Tegumen ansetzend, distal verwachsen. Saccus mit breiter Basis am Vinculum lang und schmal ausgezogen. Valven schmäler und länger als bei *merdella* Zll., am Ende allmählich zugespitzt. Aedoeagus etwa so lang wie Saccus und Valven zusammen (bei *merdella* Zll. nur 2/3 dieser Länge), mit vorgestülpter Vesica und stumpfen Chitinplättchen, die diesen Strukturen bei *merdella* weitgehend entsprechen.

Weibchen sind noch nicht bekannt !

Paratinea irakella, sp. n.

1 Männchen Typus, 1 Männchen Paratypus, Bagdad, 29. VII. 8.X.1956.

Die beiden Exemplare, Spannweite 7-8 mm, lassen die Verwandtschaft zu *merdella* Zll. schon in Flügelschnitt und Färbung erkennen, was auch, soweit an den schlecht erhaltenen Tieren zu erkennen, für die dunkelbraunen Punkte auf den Vorderflügeln zutreffen dürfte. Die männlichen Genitalien (Taf. VIII, Fig. 3) sind leicht von *merdella* Zll. und den anderen bekannten Arten der Gattung (*autochthones* Wlsm., *tripolitella* Rbl.) zu unterscheiden. Das Tegumen endet mit einem langen Uncus, der wenig gewölbt, am Ende nicht zugespitzt oder gespalten, sondern ziemlich gerade abgestutzt ist und daher auch lateral nicht schnabelförmig wirkt, wie bei den genannten Arten. Der Gnathos beginnt auch mit breiter Basis seitlich am Tegumen, ist aber ungewöhnlich lang und schlank, distal verwachsen und dort sehr stark chitinisiert. Das Vinculum endet mit dem üblichen, schlanken Saccus, der breit beginnt. Die Valven, fast parallelseitig, verbreitern sich nach der Spitze und sind dort median eingezogen, so dass dorsal ein stumpfer Forsatz und ventral eine stumpfe Vorwölbung entsteht. Der Aedoeagus hat fast genau die Länge von Saccus und Valven zusammen, ist dünn und an der Mündung, wie allgemein in dieser Gattung, mit einer vorgestülpten Vesica versehen, auf der kleine, stumpfe Chitinplättchen sitzen.

2 Weibchen, Bagdad, 13./16.V.1956, gehören, soweit sich das äusserlich überhaupt noch erkennen lässt, höchstwahrscheinlich auch in die Gattung *Paratinea* Pet. Da auf den Vorderflügeln fast überhaupt keine Zeichnung mehr zu finden ist (Schuppen und Fransen abgerieben !) und von den meisten Arten der Gattung keine Weibchen bekannt sind, lässt sich die Zuordnung zu einer der beiden hier beschriebenen Arten nicht verantworten. Ihre endgültige Determination mag daher auf einen späteren Zeitpunkt verschoben werden.

Ceratuncus affinitella Rbl. (= *libanotica* Ams. = *irakella* Ams.).

Haj Omran 2.-13.6.1956, 8 Männchen.

Die als *Tinea irakella* Ams. beschriebene Art hat sich als eine auffallend dunkle Form von *affinitella* herausgestellt (det. AMSEL).

* *Hapsifera luridella* Z.

Haj Omran 2.-13.6.1956.

Zwei Männchen von 20-21 mm Spw., die durchaus braungrau auf den Vfgl.

und dunkelbraun auf den Hfgl. sind. Sie stimmen mit Stücken aus Mazedonien und dem Karmel sehr gut überein, weichen dagegen sehr stark von *kerbelella* Ams. ab. (det. AMSEL).

Rhodobates atactopis Meyr.

Haj Omran 2.-13.6.1956, nur Männchen (det. AMSEL).

ANMERKUNG: Aus dem Museum in Leningrad erhielt ich von Herrn KUZNETZOV zwei Exemplare der *Lepidogma obratalis* Chr., die in *Horae Soc. Ent. Ross.*, p. 264, Taf. VII, fig. 36, 1876 beschrieben wurde und in Mem. Romanoff II auf Taf. VII, fig. 9 erneut abgebildet wurde. Wie diese Abbildungen bereits vermuten liessen, handelt es sich bei dieser Art um nichts anderes als um die von MANN 1873 beschriebene *Lepidogma tamaricalis* (*Zool.-Bot. Verh. Wien*, 1873, p. 124).

TAFEL I

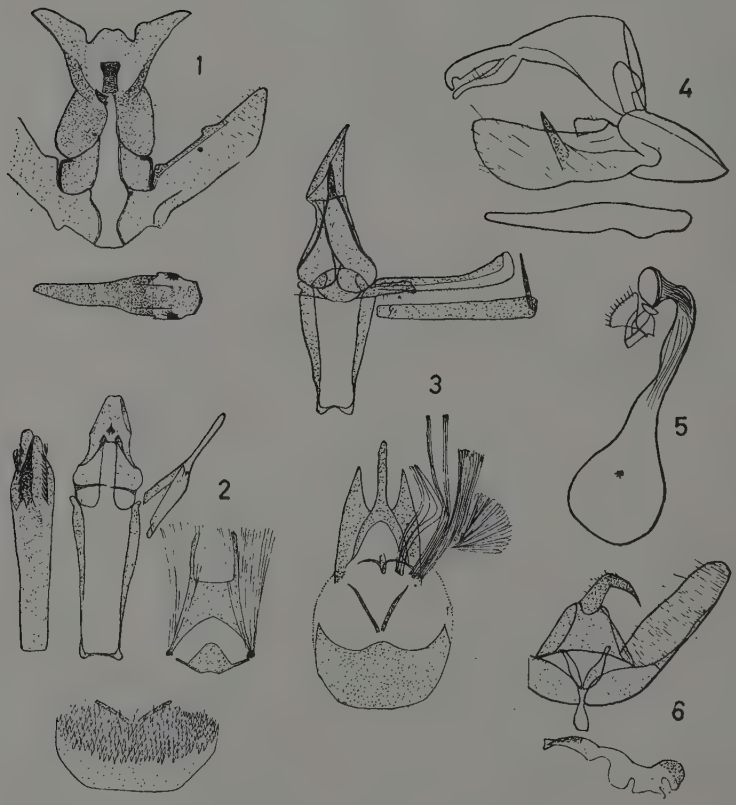

FIG. 1 : *Shirazia wiltshirei* Ams. GU. 3415, Monotypus. — FIG. 2 : *Oligochroa nigroanalis* Ams. GU. 3497, Paratypus. — FIG. 3 : *Myrlaea kurdistana* Ams. GU. 3496, Holotypus. — FIG. 4 : *Mesocrambus kurdistanellus* Ams., Holotypus. — FIG. 5 : *Agriphila brioniella* f. *subbrioniella* Blesz. — FIG. 6 : *Platyptilia irakella* Ams. GU. 3365, Paratypus.

TAFEL II

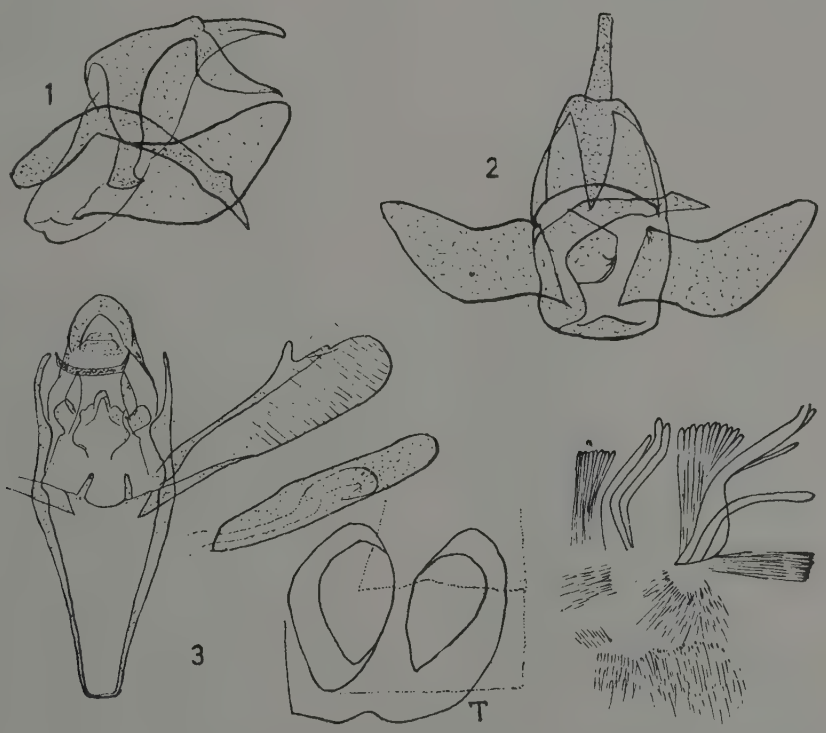

FIG. 1 : *Chrysocrambus bleszynskii* Ams. GU. 3414, Monotypus, Lateral-Ansicht. – FIG. 2 : *Chrysocrambus bleszynskii* Ams. GU. 3414, Ventral-Ansicht. — FIG. 3 : *Ephestia irakella* Ams. GU. 3409, Monotypus. (T = Tympanalorgan).

TAFEL III

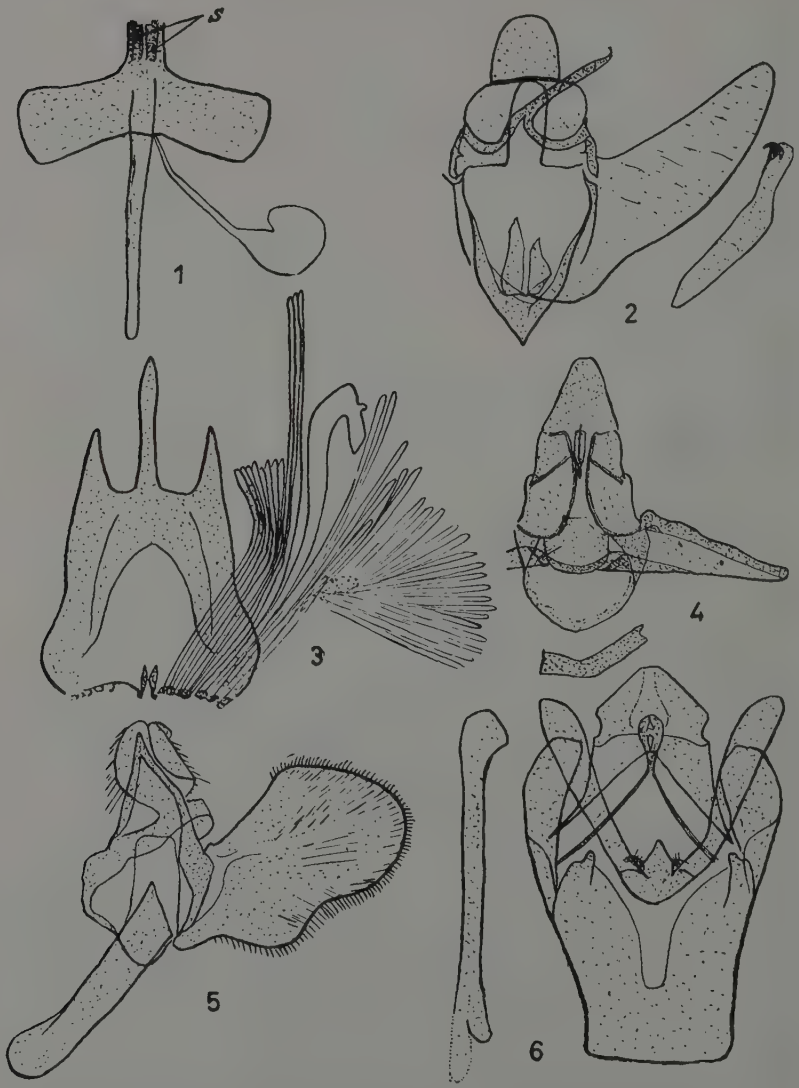

FIG. 1 : *Nymphulosis arcanella* Ams. GU. 3416, Monotypus. — FIG. 2 : *Acteniopsis kurdistanella* Ams. GU. 3412, Holotypus. — FIG. 3 : *Myrlaea epischniella* Stgr. GU. 3405, ex Marasch, Culcita. — FIG. 4 : *Epidauria omranella* Ams. GU. 3410, Monotypus. — FIG. 5 : *Epimetasia albalis* Ams. GU. 3427, Holotypus. — FIG. 6 : *Hypochalcia rayatella* Ams. GU. 3417, Paratypus.

TAFEL IV

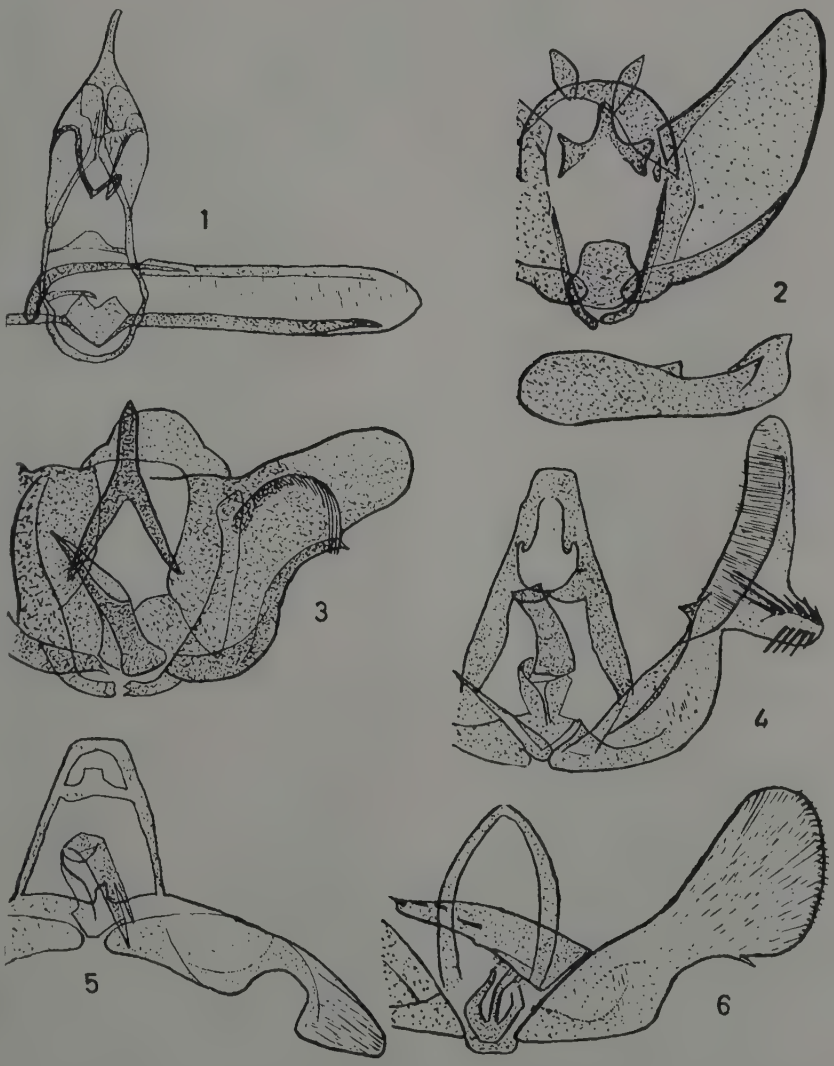

FIG. 1 : *Cnephasia nigripunctana* Ams. GU. 3367, Monotypus. — FIG. 2 : *Euxanthis kurdistana* Ams. GU. 3373, Paratypus. — FIG. 3 : *Euxanthis subflavana* Ams. GU. 3374, Paratypus. — FIG. 4 : *Phiaris kurdistana* Ams. GU. 3368, Monotypus. — FIG. 5 : *Laspeyresia coluteana* Ams. GU. 3369, Monotypus. — FIG. 6 : *Laspeyresia* sp. GU. 3370.

TAFEL V

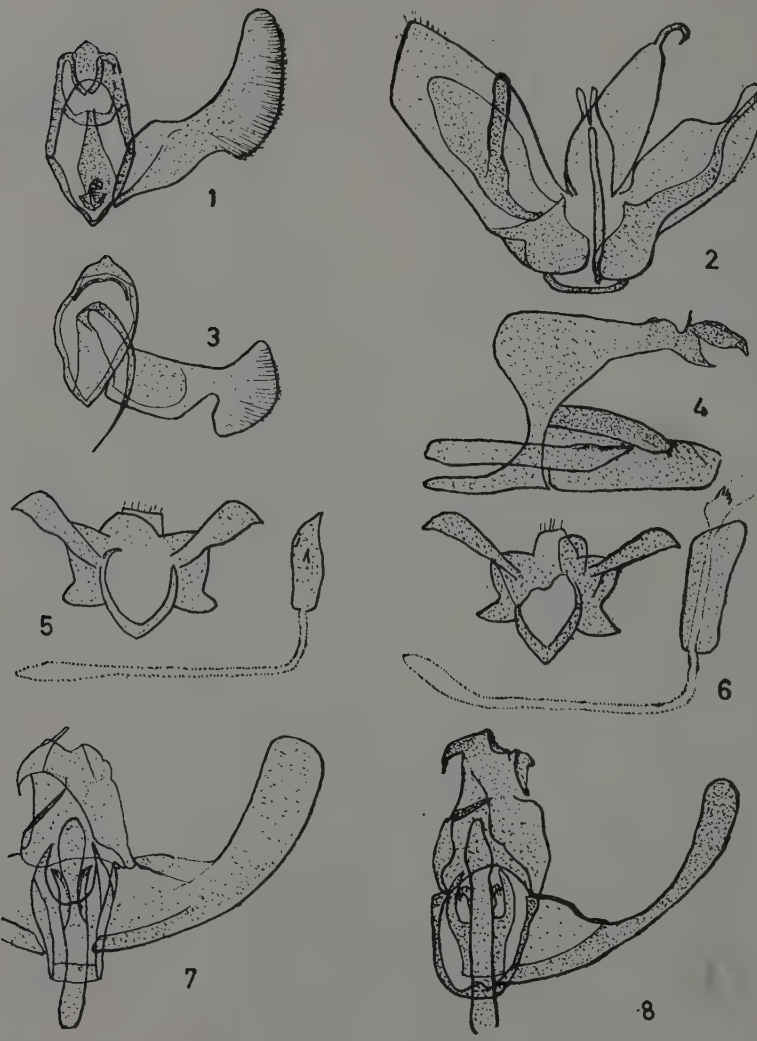

FIG. 1 : *Epiblema kurdistana* Ams. GU. 3401, Monotypus. — FIG. 2 : *Alucita rayatella* Ams. GU. 3336, Paratypus. — FIG. 3 : *Dichrorampha obraztsovi* Ams. GU. 3402, Monotypus. — FIG. 4 : *Pterolonche kurdistanella* Ams. GU. 3378, Monotypus. — FIG. 5 : *Metzneria* sp. GU. 3399. — FIG. 6 : *Metzneria* sp. GU. 3398. — FIG. 7 : *Asbolistis chthoniopa* Meyr. GU. 3384. — FIG. 8 : *Asbolistis* [*Symmoca*] *funebrella* Chrét., ex Tachdirt (Marocco), GU. 3383. Uncus lateral.

TAFEL VI

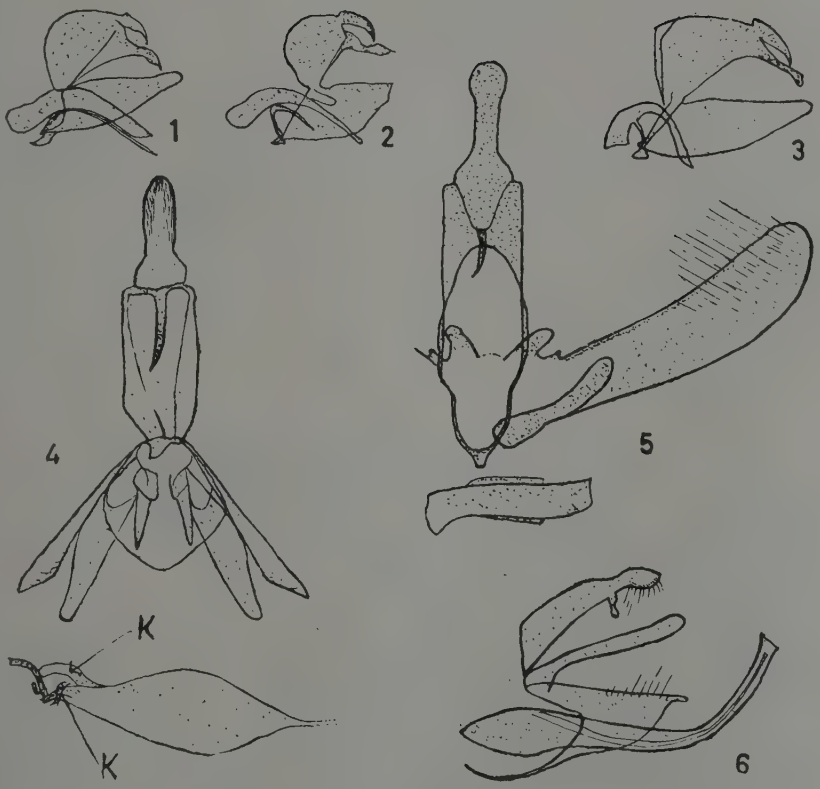

FIG. 1 : *Pleurota irakella* Ams. GU. 3381, Paratypus. — FIG. 2 : *Pleurota semiticella* Ams. GU. 3380, Paratypus. — FIG. 3 : *Pleurotopsis pygmaeella* Ams. GU. 3379, Paratypus. — FIG. 4 : *Neofaculta confidella* Rbl. GU. 3385. — FIG.5: *Symmoca fuscella* Ams. GU. 3382, Monotypus. — FIG. 6 : *Anacampsis* [*Tachyptilia*] *malella* Ams. GU. 3337, Holotypus.

Tafel VII

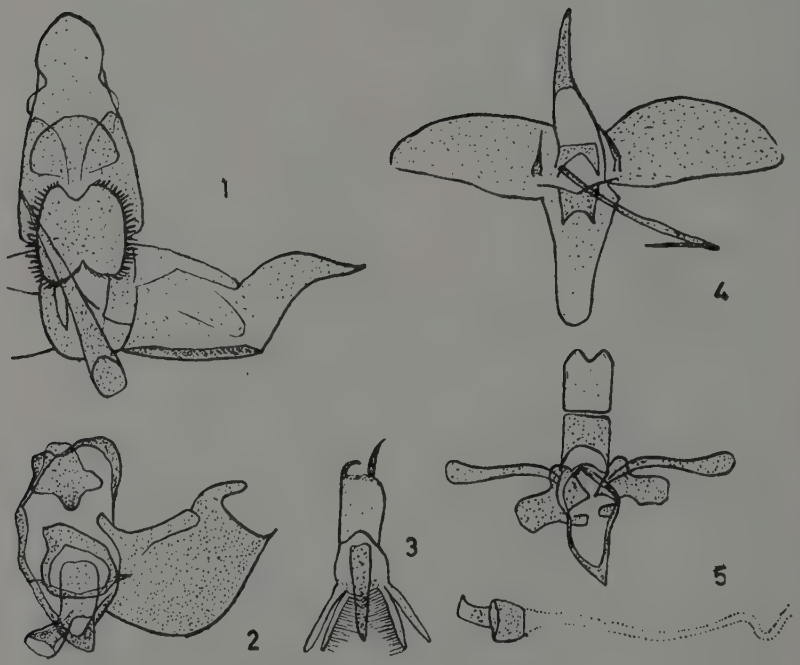

Fig. 1 : *Ethmia kurdistanella* Ams. GU. 3356, Holotypus. — Fig. 2 : *Ethmia* (?) *rayatella* Ams. GU. 3357, Monotypus. — Fig. 3 : *Tenuipenna simplicella* Ams. GU. 3403, 3404, Paratypen. — Fig. 4 : *Lithocolletis turanica* Grsm. GU. 3400, ex Bagdad. — Fig. 5 : *Metanarsia modesta kurdistanella* Ams. GU. 3376, Paratypus.

TAFEL VIII

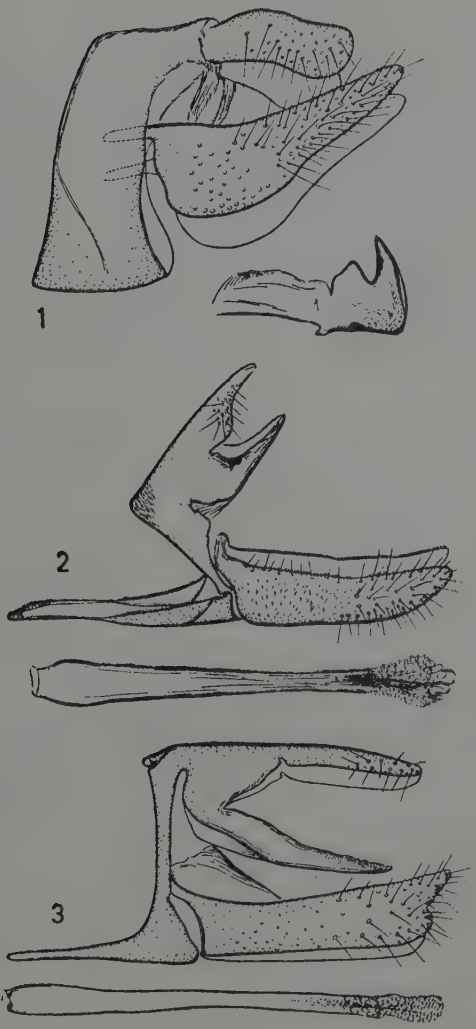

FIG. 1 : *Catabola cornuta* Pet., Holotypus. — FIG. 2 : *Paratinea striaticostella* Pet., Holotypus. — FIG. 3 : *Paratinea irakella* Pet. Holotypus.

Tafel IX

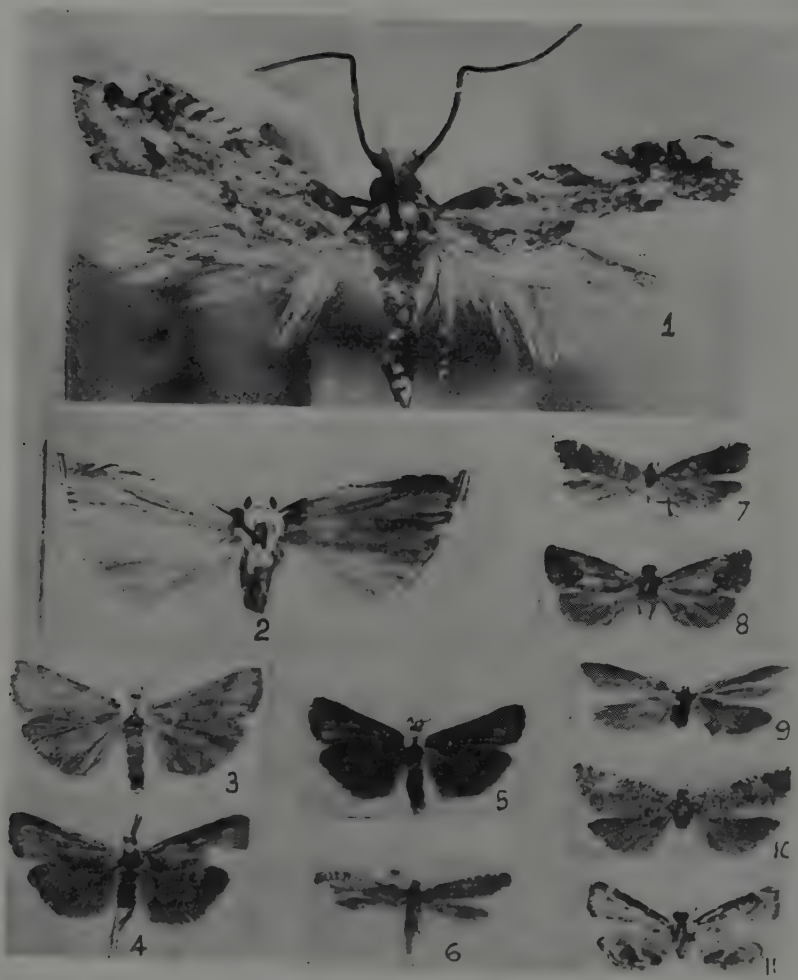

Fig. 1 : *Paratinea striaticostella* Pet. Holotypus. (Vergrösserung 11:1). — Fig. 2 : *Mesocrambus kurdistanellus* Ams. Holotypus. — Fig. 3 : *Hypochalcia rayatella* Ams. Holotypus (schwach gezeichnet). — Fig. 4 : *Hypochalcia rayatella* Ams. Paratypus (stark gezeichnet). — Fig. 5 : *Hypochalcia rayatella* Ams. Holotypus. — Fig. 6 : *Glyphipteryx bifasciella* Ams. Monotypus Weibchen. — Fig. 7 : *Anacampsis malella* Ams. Holotypus. — Fig. 8 : *Laspeyresia coluteana* Ams. Monotypus. — Fig. 9 : *Ethmia* (?) *rayatella* Ams. Monotypus. — Fig. 10 : *Phiaris kurdistana* Ams. Monotypus. — Fig. 11 : *Nymphulosis arcanella* Ams. Monotypus.

Tafel X

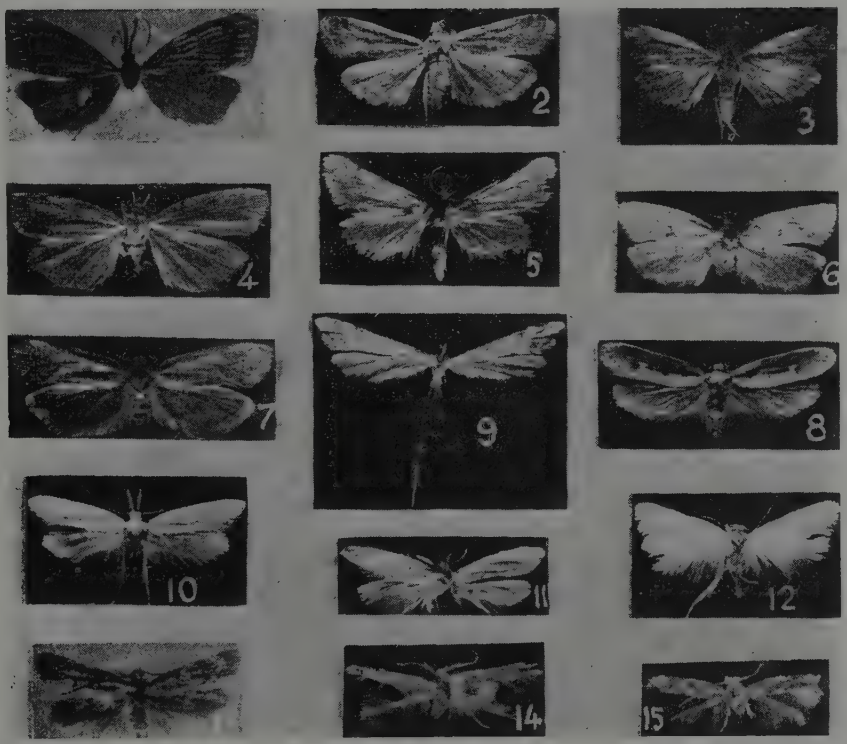

Fig. 1 : *Chrysocrambus bleszynskii* Ams. Monotypus. — Fig. 2 : *Oligochroa nigroanalis* Ams. Paratypus Weibchen. — Fig. 3 : *Myrlaea kurdistana* Ams. Allotypus Weibchen. — Fig. 4 : *Shirazia wiltshirei* Ams. Monotypus. — Fig. 5 : *Acteniopsis kurdistanella* Ams. Paratypus Weibchen. — Fig. 6 : *Euxanthis subflavana* Ams. Paratypus. — Fig. 7 : *Euxanthis kurdistana* Ams. Paratypus. — Fig. 8 : *Ethmia kurdistanella* Ams. Paratypus Weibchen. — Fig. 9 : *Platyptilia irakella* Ams. Paratypus. — Fig. 10 : *Pleurota semiticella* Ams. Paratypus. — Fig. 11 : *Pleurota irakella* Ams. Paratypus. — Fig. 12 : *Metanarsia modesta kurdistanella* Ams. Paratypus Weibchen. — Fig. 13 : *Symmoca fuscella* Ams. Monotypus. — Fig. 14 : *Tenuipenna simplicella* Ams. Paratypus. — Fig. 15 : *Lithocolletis turanica* Grsm.

STORAGE EXCRETION IN SOME INSECT LARVAE WITH BLOCKED HIND GUT

[*Diptera* and *Neuroptera*]

(with 2 Text-Figures and 1 Table)

by MAHMOUD HAFEZ, M.SC., PH.D., F.R.E.S.,
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In the course of ecological and biological studies on some desert insects in Egypt (HAFEZ and EL-MOURSY, 1956 *a* and *b*, and EL-MOURSY 1959), it was found that the larval period takes under the most favourable conditions no less than one year, normally several years. The anatomical study of these larvae revealed that the hind gut is blocked by a solid mass of cells throughout the long larval duration that no excrement can pass from the mid gut to the anal opening. This phenomenon lead the present authors to study how larvae feeding in such a manner, with their hind gut blocked, do excrete.

Three groups of desert insects' larvae were chosen for this study. The first is the pit-building worm-lion *Vermileo vermileo* L. (Diptera-Rhagionidae), the second is four nemopterids namely *Pterocroce arenaria* Roux, *Nina withycombei* Navas, *Nina alfierina* Navas and *Klugina aristata* Klug (Neuroptera-Nemopteridae) and the third group is three pit-building ant-lions namely, *Morter hyalinus* Oliv., *Cueta puella* Navas and *Cueta longula* Navas (Neuroptera-Myrmeleonidae).

Procedures for the quantitative estimation of the main excretory nitrogenous constituents (total nitrogen, ammonia, urea and uric acid) were the same as previously described by one of the present authors (KHALIL and HAGGAG, 1955) in the analysis of the urinary deposits of tortoises.

RESULTS AND DISCUSSION

The hind gut of all the species under investigation is blocked throughout the whole larval period. In *Vermileo*, the hind gut is opened before pupation to let

pass the residual accumulated contents of the gut. The contents come out in the form of one or two hard spherical blackish pellets. In the other two groups, the nemopterids and myrmeleonids, the hind gut becomes opened at pupation, during which time it functions to allow the passage of silk secreted by the Malpighian tubules for the construction of the spherical cocoon within which the insect pupates. This necessitates that getting rid of the stomachal contents be postponed till the emergence of the adult. Thus half an hour after emerging from the cocoon, the adult discharges from the anus a single elongated hollow pinkish-buff to grey pellet (Figs. 1 and 2).

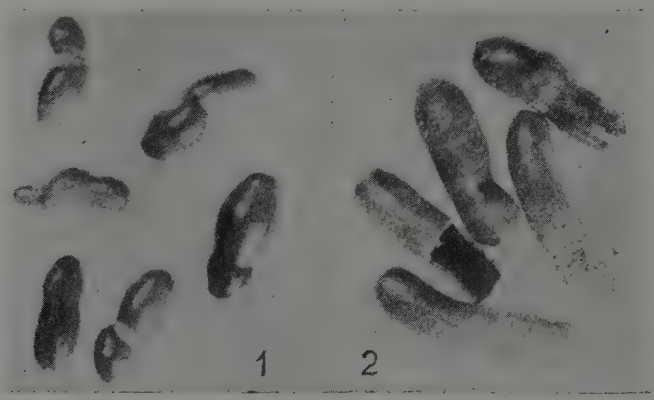

FIG. 1: Faecal deposits of *Pterocroce arenaria*, × 10.—FIG. 2: Feacal deposits of *Morter hyalinus*, × 7.

The results of the analysis of the faecal pellets of the three groups of insects are summarised in Table I. The weight per each pellet was about 0.4 mgm. in the nemopterids, 0.9 mgm. in *Vermileo* and 2.6 mgm. in the myrmeleonids. Urea was completely absent. Ammonia was in traces as it formed from 1.77 to 3.23% of the total nitrogen of the pellet. The main nitrogenous constituent of the water soluble portion of the pellet was in the form of uric acid as it formed 46.58, 67.16 and 28.12% of the total nitrogen of the pellet in *Vermileo*, the nemopterids and the myrmeleonids, respectively. The corresponding values for the water soluble nitrogenous constituents were 75.25, 72.23 and 34.87%, respectively. The lithium hydroxide soluble portion of the water insoluble part contained traces of uric acid. It gave positive tests for proteins. This portion seems to be formed of cell debris during the development to the adult insect.

It is well-known that animals enjoying plenty of water-supply, excrete mainly ammonia or urea as a result of nitrogenous metabolism, but those which have not enough water at their disposal, transform their excretory nitrogenous

metabolites into insoluble solid relatively non-toxic uric acid crystals; and thus conserve water. The present insects are desert-dwellers running short of water. HAFEZ and EL-MOURSY (1956 *a*) found that the larvae of *Vermileo* can withstand thirst and starvation for long periods varying from 3 to 12 months according to their age and size. Storage excretion in the larvae, the main excretory constituent of which is uric acid (Table I) seems to be an adaptation to counteract the water shortage.

TABLE I

Nitrogenous constituents of the storage excretory products of insect larvae (in one gram sample)

Species	Vermileo		Nemopterids		Myremeleonids	
Number of samples examined	70		160		89	
Average weight/each sample (mgm.) ...	0.88		0.43		2.62	
Components	mgm.N	as % to T.N.	mgm.N	as % to T.N.	mgm.N	as % to T.N.
Total Nitrogen (T.N.)	250.2	100.00	188.5	100.00	165.6	100.00
T.N./water soluble portion	188.20	75.25	136.20	72.23	57.75	34.87
As ammonia N.	8.07	3.23	5.45	2.89	2.93	1.77
As urea N.	0.00	0.00	0.00	0.00	0.00	0.00
As uric acid N.	116.50	46.58	126.60	67.16	46.56	28.12
T.N./LiOH soluble portion of the water insoluble portion	59.16	23.64	51.77	27.46	101.10	61.03
As uric acid.	0.24	0.10	1.51	0.80	2.05	1.24

From the present study, it is clear that although such insects have their hind gut blocked, yet they precipitate their excretory end products in their gut in the form of insoluble pellets till they can get rid of them when the hind gut is opened, either few days before pupation as in *Vermileo* or when the adult is formed as in the nemopterids and myrmeleonids.

WHEELER (1930) stated that in some groups of insects namely the Neuroptera (Planipennia), the Strepsiptera, the Hymenoptera with the exception of the Phytophaga and the Vermileoninae (Diptera), the stomach or mid gut is shut off from the hind gut during the larval stage. However, these insects seem to accumulate the end products of metabolism during the larval period as storage excreta in their guts till they can get rid of them either on pupation or adult formation. Such storage excreta is also known in other animals. In the Dipnoid fish (lung-fish) ammonia is excreted as long as water is available, but when the rivers dry up, the fish shut themselves in cocoon-like structures in the mud, stop ammonia excretion and form in their gut storage excreta in the form of a solid ball of urea which is got rid of when the rivers fill again the following year (SMITH, 1930).

This type of storage excretion inside the gut clearly differs from that storage excretion in the urate cells of the fat body which is known to occur in some insects. In the latter case, uric acid resulting from the cell metabolism is collected and deposited within the urate cells scattered in the fat body. This type of storage excretion occurs in the Collembola, which lack Malpighian tubules, in the cockroach in which the Malpighian tubules are said to take no part in uric acid excretion, and during the larval stage of the honey-bee, *Apis mellifica* L., where the Malpighian tubules end blindly and have no connection with the hind gut (WIGGLESWORTH, 1950).

SUMMARY

(1) Some desert species of the order Diptera and the order Neuroptera were found to take no less than one year, normally several years during the larval period, during which time the hind gut is blocked and no excrement passes out.

(2) On pupation in one species and on adult formation in the others, small pellets are discharged from the anus which were found by analysis to be storage excreta, containing considerable quantities of uric acid.

(3) Excretion of uric acid as the main excretory nitrogenous constituent of the storage excreta of these desert-dweller insects, helps in water conservation.

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STUDIES ON DESERT INSECTS IN EGYPT

III. ON THE BIONOMICS OF *ADESMIA BICARINATA* KLUG

[*Coleoptera*: *Tenebrionidae*]

(with 7 Text-Figures and 10 Tables)

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CONTENTS

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I. INTRODUCTORY AND HISTORICAL

The desert, occupying the great majority of the area of Egypt, provides an interesting and important field of biological and ecological research. This is because, inspite of its aridity and the common occurrence of extreme climatic conditions as well as the scantiness of food and water supply, the desert contains a variety of insect life. The desert insects, representatives of widely different families, appear to be closely related in their adaptation and resistance to such severe conditions, which seem to have no ill effects on their well being or their successful existence.

The Egyptian desert is dissected by several Wadies relatively rich in flora and in which the environmental conditions are less severe. These Wadies provide a great variety of micro-climates in localities sometimes only few feet apart, thus giving the organisms living within, at their disposal a wide range of life conditions.

Unfortunately in Egypt, desert Entomology received but little attention as most efforts were directed first and foremost to insects of medical and agricultural importance. Therefore, an attempt for contributing to our knowledge on desert insects and for stimulating research on their biology and ecology, was started few years ago in the Department of Entomology, Faculty of Science, Cairo University, by the worm-lion *Vermileo vermileo* (Diptera, Rhagionidae), and the results of studies on this subject appeared in two papers (HAFEZ and EL-MOURSY, 1956).

The present paper, which is the third in our series "Studies on desert insects in Egypt", deals with the bionomics of another remarkable inhabitant of Egyptian deserts, *Adesmia bicarinata* Klug (Fig. 1). It is one of the several species of Adesmi-

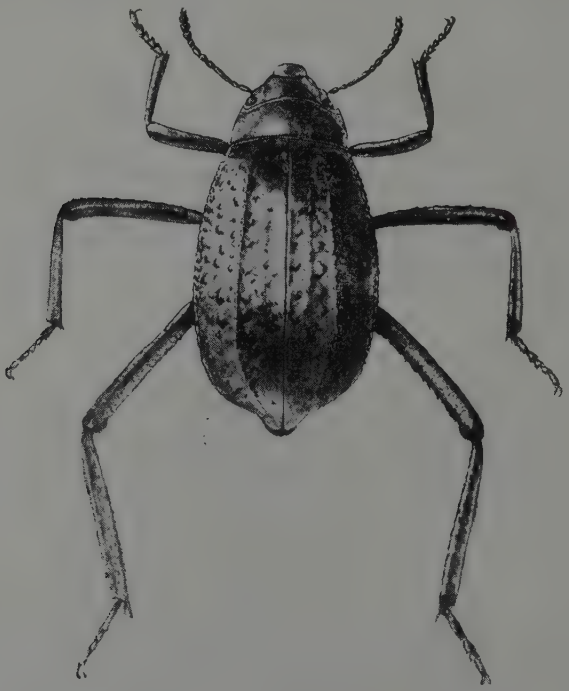

FIG. 1: *Adesmia bicarinata* Klug, × 4.5.

inae found in Egypt, large in size varying in length from 11-20 mm., black in colour and commonly seen wandering about on sand by day, taking no refuge from the mid-day sun, but retreating under stones or shrubs at night or during adverse conditions. This insect is morphologically characterised by its dorsum being convex and its integument being hard and black, clothed with minute spines and delicate hairs, especially the prothorax. Dorsally, the elytra are firmly soldered to the body

of the insect, with their lateral extremities deflected ventrally. They cover the majority of the mesotergum and all the posterior terga. The elytral surface is provided with conspicuous tubercles arranged in longitudinal rows.

A. bicarinata can be separated from other Egyptian *Adesmia* species by its hind tibiae being characteristically flattened antero-posteriorly. Both sexes of this species are difficult to be differentiated from each other, except that the female is generally of larger size, being slightly broader than the male with somewhat shorter legs. The former has an average breadth of 9.5 mm. and an average length of 16 mm. The male, on the other hand, is about the same length of the female but with an average breadth of 8 mm.

The review of literature reveals that no detailed studies have been previously made on *Adesmia*. Some authors (e.g. FISCHER 1822; KLUG, 1830; SOLIER, 1885, GEBIEN, 1906-1921, BOEHM; 1908; ANDRES, 1919-1921 and 1931), however, gave short notes on the geographical distribution of the various species, their nomenclature, taxonomy, etc. More recently KOCH (1934), KOCH and SCHATZMAYER (1934) identified a number of sub-species of *Adesmia* and described the distinctive characters of the Egyptian species. According to these authors, two sub-species of *A. bicarinata* occur in Egypt, one collected from Sinai which received the name *Adesmia* (*Oteroscelis*) *bicarinata glabrior* Schatz., and the other collected from middle Egypt which received the name *Adesmia bicarinata bicarinata* Klug. KOCH in a later account (1944), reclassified the Adesmiinae of Savannah regions of tropical and sub-tropical Africa and gave a key of the palaearctic and tropical genera and sub-genera.

Perhaps the only information available on the ecology of *Adesmia* is that of BUXTON (1924) who described briefly the relation between the temperature of the external environment and the sub-elytral space and the body temperature of *Adesmia ulcerosa*. Interesting notes were also given by this author (1923) about these beetles in his book "Animal life in the desert".

Apart from this account, no work seems to have been done on *Adesmia* nor on other wingless Tenebrionid beetles.

The literature also reveals that *Adesmia bicarinata* is not of world wide distribution. It has been recorded from the palaearctic region from Persia and Egypt. In the latter country, it occurs in the Eastern (including Sinai) and Western deserts close to the Nile Valley. The junior author collected this species in large numbers from three main localities in Egypt, as follow:

(1) A vast area in the form of an elevated Plateau about 15 km. south east of Cairo and including Wadi Hof, Wadi Digla, Wadi Ghandali, Wadi Rechid, Wadi Hamadol, Wadi El-Racham, Wadi Garawi, Wadi El-Tih and Wadi Liblab.

(2) The desert areas fringing the Suez Road extending 60 km. east of Cairo.

(3) The Giza Pyramids area (in small numbers).

ANDRES (1913) recorded *A. bicarinata* together with sixteen other species of *Adesmia*, from various localities of the Egyptian territory including Sinai, Delta, Upper Egypt, Mariut, Eastern desert, the Wadies near Cairo, etc.

II. MATERIAL AND METHODS

The individuals used in the course of the present work were brought fresh from the desert and stocked under laboratory conditions. They were placed in large vials with a layer of fine sand 2 cm. deep and were supplied daily with fresh quantities of Rigla plant (*Portulaca oleracea*) as food.

The study of the insect in its natural habitat necessitated regular frequent excursions to Wadi Hof and Wadi Digla about 15 miles south-east of Cairo where most of the ecological work was conducted throughout the years 1954 and 1955. During the period of insect abundance and activity (October to May), excursions were made more frequently, sometimes daily.

Meteorological records of the insect micro-habitat under shrubs and patches of vegetation together with the soil surface and air temperatures at 75 cm. above the soil surface of the open wadi, were made regularly during these visits. Hourly records of temperature and relative humidity were taken during a fixed daily period starting from 8 a.m. to 5 p.m. Macro-climatic records were obtained from Helwan Observatory in the neighbourhood of the wadies.

Careful observations on the behaviour of the adult beetles in the wadies, their food and their feeding habits, abundance, distribution and daily activities, etc., were carried out during the different seasons of the year.

Concurrently with these field studies, repeated attempts were made to breed the insect in the laboratory. For this purpose, beetles were collected from the field early in the season (October) when they start appearing. They were then segregated in pairs and placed, each in a glass vial with sufficient food. Successive trials, under both laboratory and controled conditions, to obtain all the developmental stages and have the life-cycle completed from egg to adult, were in vain. Hatching larvae usually died after the third moult. One larva, however, succeeded to moult to the seventh instar and then died. This was probably due to failure in simulating the natural habitat of the larva in the laboratory. In the normal environment, the larva lives in a certain micro-climate deep in the soil under the shrubs possibly feeding on plant roots. Young developing larvae were sometimes found and dug out from the soil and brought to the laboratory but in no case they continued to develop or reach full maturity.

III. NATURAL ENVIRONMENT

1. Localities

Adesmia bicarinata is commonly found in certain valleys or wadies scattered in the desert south-east of Cairo. These wadies dissect an extensive area, in the form of an elevated limestone plateau 318 metres above sea level, and its surface is usually blackened by the "desert varnish", and covered with sand grains, and in

certain places with powdered gypsum. Among these wadies, Wadi Hof, Wadi Digla, Wadi Ghandali, Wadi Rechid, Wadi Hamadol, Wadi El-Racham, Wadi Garawi, Wadi El-Tih and Wadi Liblab being near to Cairo and more easily accessible, are of special interest. However, the field studies of the present work were restricted to Wadi Hof (Fig. 2) and Wadi Digla (Fig. 3).

Wadi Hof and Wadi Digla are respectively about 4 and 10 km. to the north of Helwan observatory. They run parallel to each other, extending in an east-western direction, the first wadi for 37 km. and the second for 35 km. to join the Nile Valley. Both wadies are dry, except in the rainy seasons when accumulations of rain-water in the form of temporary wells are formed in the wadi-beds.

The two wadies are lined by steeply inclined cliffs more than 220 metres high. These cliffs give rise to water-falls during rainy seasons. Stones and pebbles cover the central part of the wadi-beds, but the sides are mainly of silt and are also covered with dense vegetation, of which *Zilla spinosa* is the dominant plant in Wadi Hof while *Anabasis setifera* predominates in Wadi Digla. A preliminary list of the various plants, birds and insects found in Wadi Digla was given by WILLIAMS (1924). Nearly all orders of Insecta are represented by many species inhabiting the wadies and form a great part of their fauna. The family Tenebrionidae is well represented by different species of *Adesmia*, *Pimelia*, *Blaps*, *Erodius*, *Zophosis*, etc. *Adesmia bicarinata*, *Adesmia longipes*, *Adesmia dilatata* and *Adesmia montana* are of common occurence.

2. Climatic conditions

Temperature

The temperature of the wadies differs greatly from that of the open desert. WILLIAMS (1924) most tentatively gave records of both the maximum, minimum and

TABLE I

Mean monthly temperature and humidity conditions prevailing in Wadi Digla (*)

Month	Temperature				Relative humidity
	a	*b*	*c*	*c–b*	
January	17.9	19.1	20.1	1.0	43.5
February	18.7	21.8	27.0	5.2	38.9
March	22.5	23.7	32.5	8.8	54.4
April	27.5	27.5	38.4	10.9	44.3
May	33.9	34.6	48.1	13.5	39.4
June	32.2	33.7	46.4	12.7	36.8
July	35.2	35.7	50.1	14.4	42.3
August	35.3	35.6	49.8	14.2	32.4
September	31.4	30.8	44.5	13.7	43.6
October	30.4	30.8	38.5	7.7	47.8
November	28.7	25.7	29.2	3.5	37.1
December	17.7	19.6	22.4	2.8	51.3

(*) *a*=air temperature; *b*=shrub-shade temperature; *c*=soil surface temperature.

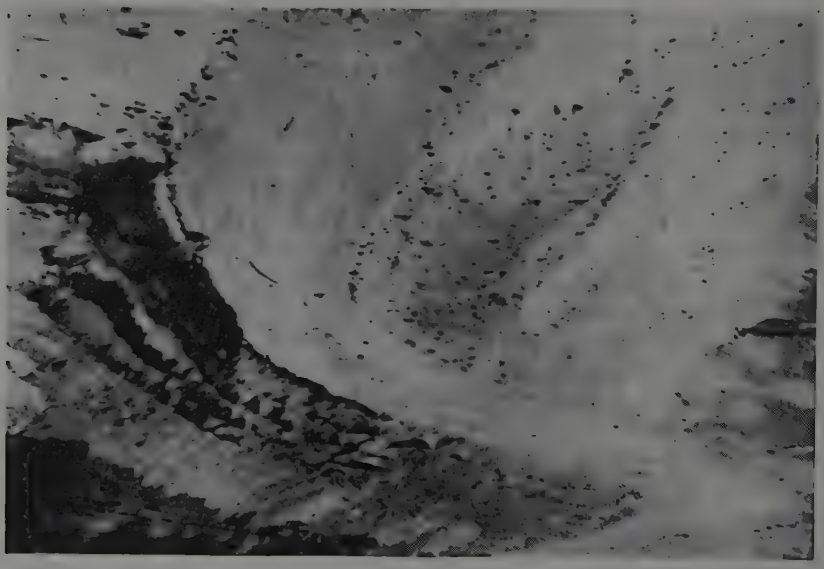

FIG. 2: General view of Wadi Hof.

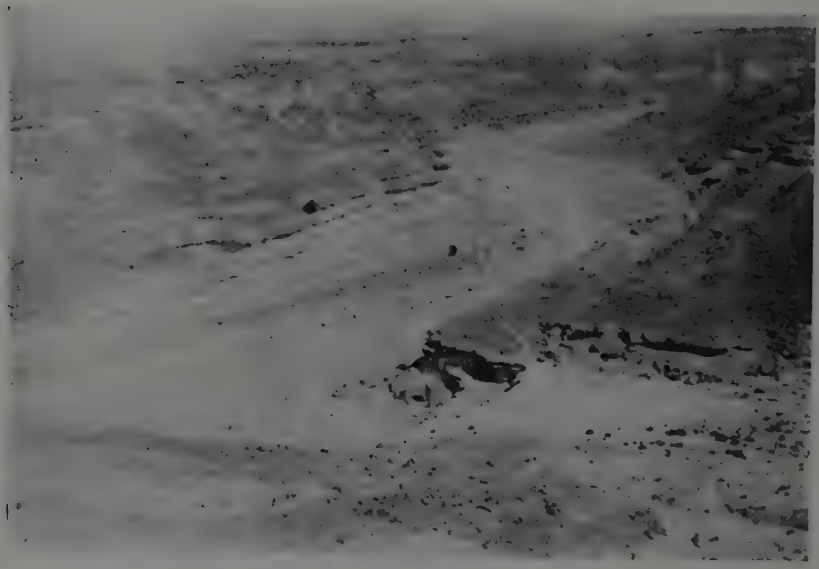

FIG. 3: General view of Wadi Digla.

daily range of temperature together with relative humidities prevailing for a week in August 1922 and another week in March 1923, in Wadi Digla. He concluded that the mean daily range of shade temperature is not as one usually associated with desert conditions and that the maximum shade temperature is some degrees below that in the open wadi.

The mean monthly air, shade or soil temperature (Table I), increases gradually from low values in February to relatively high values in both April and May. From January to March, it was noticed that the three temperatures generally rise and fall together as the day advances, The air temperature is comparatively slightly lower than the shrub shade temperature in February and March, while it was almost equal to it in both April and May. Both temperatures, however, were considerably below that of the soil surface temperature at any hour of the day and thus the difference between the soil surface temperature and the shrub shade temperature reached a minimum of about 2.8°C. in the early morning in February and a maximum of 21°C. in the early afternoon in May.

Comparing the daily change of temperature during the four months of maximum activity of *Adesmia* (February-May), it was observed that the maximum shrub shade temperature in February reached 24.8°C. while the maximum soil surface temperature reached 33.8°C. (at 1 p.m.). The corresponding figures for March were 26.3°C. compared with 39.2 °C.; in April they were 29.7°C. and 47°C., and for the first half of May they were 38.5°C. and 59.5°C., respectively. The air and shrub shade temperatures, however, tended to show very slow and gradual variation in their daily temperature change, and one and the same temperature seemed to be retained for several hours. This apparently was not the case with the soil surface temperature which tended to heat up and cool down rather rapidly.

Thus, the conditions prevailing in the Wadies provide the beetles in their normal habitat with various micro-climatic conditions which they can make use of during their normal activities and daily requirements.

Relative humidity

The mean relative humidity during 1954 and 1955 did not show regular fluctuations within the various months. The mean minimum relative humidity was 54.4% attained in March, while the mean minimum relative humidity was 32.4% in August. However, daily relative humidity varied greatly from comparatively high values in the morning to lower values at mid-day and then back to high values again towards the evening.

During the four months of insect activity (February-May), there seems to be no consistency in the values of the mean monthly relative humidities inspite of the wide variation of temperature during that period (Table I).

Rain

The total amount of rainfall during both years was obtained from Helwan observatory about 4 km. from Wadi Hof. In 1954, a total of about 23.6 mm. of

rain fell on few days in February, April, October, November and December. In 1955, on the other hand, only 17.2 mm. of rain fell during January, November and December. Generally, rainfall in both wadies is rather scanty but rain water may be accumulated in small pits in the wadies that may persist for few days.

IV. FIELD OBSERVATIONS ON THE ADULT

1. Habits

Normally, the beetles are active during the day time, in the open wadi (in February, March, April and May), as long as the soil surface temperature is not above their tolerance. But when this temperature increases, beetles seek shelter and assume their activity under shrubs or other shady situations where temperature is much lower. On windy days, beetles are often seen to bury their heads and prothorax in the soil under bushes, probably to gain a firm hold of the soil and protect themselves from being blown by the wind.

The beetles are no great wanderers, and seemed to have no tendency to migrate far from their sheltering places, even if climatic conditions are apparently favourable. For instance, eight beetles out of ten marked with cellulose paint and released in Wadi Hof, were recovered after ten days at a distance of about 100 metres.

Close and frequent observations in Wadi Digla and Wadi Hof indicated that temperature plays a major role in affecting the daily activity of *Adesmia bicarinata* in the field.

In February and March, beetles were noticed to start their daily activity rather late in the morning (about 11 a.m.), quitting their hiding places only when the soil surface temperature of the open wadies was above 20°C., the shade shrub temperature at that time was 18°C. Beetles, however, remained active in the field all day when the mean daily maximum temperature of the soil surface reached on an average 33.8°C. in February and about 39°C. in March. On the other hand, in April the beetles started activity earlier in the morning (9 a.m. or probably earlier) when the soil surface temperature was 27.7°C. while the shade temperature was about 23°C. The beetles, however, remained active in the open wadi only till midday when the soil surface temperature was slightly above 40°C. (e.g. 43°C.); but when the soil surface temperature increased and reached 47°C., the beetles immediately took shelter under shrubs in the shade of the rocks and under other patchy vegetation where the mean shade temperature was 30°C. Neverthless, the beetles then resumed activity in the afternoon when the soil surface temperature dropped again to 40°C.

From these observations, it may be understood that the beetles seem to accomodate themselves to temperature of the environment. They seem also to tolerate high temperature of the field slightly above 40°C. Higher temperatures

(e.g. 47°C.) apparently affected the activity of the beetles particularly in exposed areas and they mostly took shelter in shady situations where the temperature was considerably lower. It seems also that the lower threshold of activity of the beetles lies above 20°C.

2. Relative abundance

Adult *Adesmia bicarinata* in the field was commonly met with during late winter, spring and early summer months, i.e. from November to the middle of May. Throughout the summer and early autumn the adult beetles completely disappeared. There is a good deal of evidence, however, indicating that all the adults may die during that period of the year. This is mainly supported by the number of the freshly dead beetles collected from under shrubs and other situations, on the one hand, and by experiments done in the field, on the other hand.

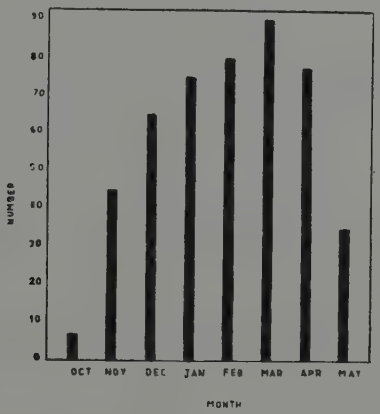

FIG. 4: Histogram showing the relative abundance of the adult.

Insect abundance (Fig. 4) in the field was determined by collecting adult beetles from Wadi Digla and Wadi Hof once or twice every month in both years, 1953 and 1954. Collections were made all over the wadies, particularly from beneath the bushes, their sheltering places. The figures were then reduced to number of beetles per one kilometre space and this was chosen as an arbitrary measure for abundance.

Table II shows the mean number of beetles per one kilometre of the wadi collected at the specified dates.

Adesmia bicarinata started appearing in the field during October when only seven beetles were collected. The population in the field (Fig. 4) then increased rapidly and an average of about 5 times that number was obtained in November. A gradual increase in the beetles population then set in and the peak of abundance occurred

TABLE II

Number of insects per one kilometre, at different dates.

Date	Number per km.	Date	Number per km.
20.10.1953	7	25.4.1954	75
25.11.1953	45	10.5.1954	35
28.12.1953.....	65	June.....	0
30.1.1954.....	75	July	0
28.2.1954	80	August	0
30.3.1954	90	September	0
20.4.1954.....	80		

in March when on an average a maximum number of 90 beetles were collected from the wadi. A gradual drop then occurred in April, followed by a sharp drop in the first half of May (Table II). In the second half of May and the following months the beetles completely disappeared from the field and only their dead bodies were found beneath shrubs and other situations in the wadies.

The disappearance of the beetles is not abrupt but rather gradual. Table III shows the number of beetles collected during a period starting from 17th of April to 21st of May. The number generally dropped from 60 beetles on the 17th of April to zero beetles on the 21st of May. Repeated and carefull search for adults all over the wadies revealed their entire absence from late May to the beginning of October.

TABLE III

Number of beetles per one kilometre collected from Wadi Hof.

Date	17.4	21.4	29.4	6.5	9.5	12.5	16.5	21.5
Number	60	45	36	15	8	5	2	0

It seems probable that the disappearance of the beetles is correlated with high mortality of the adults. This is indicated by the freshly dead beetles collected in large numbers from the wadies in late May. In fact the cause of this mortality is not fully understood but it may be due to the excessive heat of May, when the soil surface temperature may be as high as 59.5°C. Mortality may also be due to normal ageing of the beetles.

From these results, it may be also concluded that adults appear once every year.

3. Food and feeding habits

Adesmia is mainly vegetarian in habit, deriving its food from all shrubs and green plants in its natural environment without an apparent preference to any one particular plant. All parts of the plant, particularly the succulent leaves, the

flowers, the small shoots, the roots and the seeds provide a rich food supply for the beetles in the field. It was also observed that although *Zygophyllum*, which has a high percentage of salt and is unpalatable by many desert animals, was devoured by the adult beetles. It seems also that the beetles are sometimes saprophytic in habit as they were seen to feed on decayed parts of the plant as well as on a dead lizard. On one occasion, the beetles were encountered feeding on human excrement but not on camel dung frequently found in the wadies. They also attacked and devoured various other Tenebrionid larvae that happened to appear on the soil surface.

On the other hand, these beetles showed a marked resistance to lack of food, as was demonstrated experimentally. Adult males and females were collected from the field in March and kept with no access to any type of food. Five males and five females were tested and although the error included in this method, among other things, was the difference in the age of the beetles tested, randomisation in collection may reduce this error.

From the results shown in Table IV it seems that the females were more resistant to starvation than the males. The minimum period of resistance of the males under these conditions was 11 days compared with 18 days for the females. Maximum period for both sexes, however, was the same (19 days).

TABLE IV

Effect of starvation on the adult beetles under laboratory conditions.

Number of dead beetles	Sex	Number of days resisted
1	male	11
1	male	12
2	males	18
2	females	18
1	male	19
3	females	19

Beetles kept without food at the constant temperature 32°C. and 50% R.H. were less able to resist starvation and the males died after 10 days while the females after 11.5 days.

This high resistance of the beetles to starvation, may be some kind of adaptation to adverse desert conditions.

4. The beetles under different desert conditions

The possible effect of different desert conditions on adult *Adesmia* was studied in a series of preliminary experiments.

Five square areas each 2 × 2 metres wide, very close to each other but different ecologically, were selected in the field; one area was bare desert; the

second area contained a short *Zilla spinosa* shrub; the third a tall *Zilla spinosa* shrub; the fourth an *Anabasis setifera*, while the fifth area contained patchy vegetation with some rocks. These areas were enclosed and separated from each other by thin tin sheets fixed 8 cm. deep in the soil and 7 cm. above the soil level. Care was also taken that no shade was reflected from the wall in the first bare area. Each area was provided with 20 beetles, 10 males and 10 females, collected at random in the field. The beetles in the bare area were supplied daily with sufficient food. Maximum and minimum air temperature of each area were measured and the experiment was carried out in April.

The shortest life duration of the beetles occurred in the bare area where high mortality took place particularly on the fifth day of exposure (15 out of 20 beetles died on that day). However, 100% mortality took place on the seventh day of exposure.

In the second area with short *Zilla spinosa* and the fifth area with patches of vegetation and rocks, the life of the beetles seemed to be considerably prolonged. A 100% mortality took place after 27 days.

In the third and fourth areas with tall bushes of *Zilla spinosa* and *Anabasis setifera*, the adult life of the beetles seemed to be still prolonged and total mortality occurred after about 34 days.

The different mortality rates obtained by the above experiments in the five different areas seem to be highly correlated with maximum and minimum temperatures prevailing in the various areas. Whereas the average maximum temperature in the bare area reached 53°C. and the minimum temperature 9°C., the average maximum temperature in the second area was considerably lower and reached roughly 40°C. and the average minimum 11.5°C. In the third and fourth areas the average maximum temperature was still lower and was nearly 39.5 and 36.°C., respectively, while the average minimum was roughly 11.5°C.

Thus, it could be seen from these results that temperature in the natural environment of the beetles might be the most significant factor affecting directly the adult's activity and life in the field. Objects that provide suitable shade, i.e. giving a range of different temperatures, seem to be of importance in reducing the beetles mortality rate.

5. Heat stupor and resistance to high temperatures

Furthermore, the effect of high temperature on the beetles was studied in the field and in the laboratory.

A round specimen jar provided with a layer of sand at the bottom and with ten beetles of both sexes were exposed the whole day in April in Wadi Hof to the direct action of the sun. Temperature of the sand at the bottom of the jar and the relative humidity of the air were recorded every 15 minutes.

Beetles in the jar behaved normally the whole morning (up to 11.30 a.m.) when the temperature of the substratum reached about 46°C. and the relative

humidity was 37%. At 11.45 a.m., when the temperature of the sand at the bottom of the jar increased to 47°C. (R.H. 36%), the beetles became erratic, excited, and tried to climb the glass wall of the jar apparently to escape this high temperature. However, when the sand temperature reached 50°C. (R.H. 33.0%) three insects became moribund, fell upside down and attained a state of heat stupor. The rest of the beetles showed the same phenomenon when the sand temperature reached 53°C. (R.H. 32.0%). At 55°C. and after one hour of exposure to this temperature, all the beetles died.

The same experiment was repeated in the laboratory in an incubator with constant relative humidity (about 35%) and with a regularly rising temperature (one degree every 10 minutes). Ten beetles in a similar jar were introduced in the incubator and were observed through the glass door. Results similar to those in the field were also obtained in the laboratory and the insects were greatly excited when the temperature of the incubator reached 47°C. whereas they showed a state of heat stupor and ceased to move at 53°C.

The time the beetles were able to resist high temperatures was also tested in laboratory (Table V). This was carried out by subjecting groups of beetles to different high temperatures and recording the time at which heat stupor was manifested.

TABLE V

Effect of high temperature on Adesmia (*heat stupor*). *Field experiments.*

Time	Percentage R.H.	Temperature in °C.	Heat stupor
10.00 a.m.	43.0	43.0	0
10.15 a.m.	42.0	43.5	0
10.30 a.m.	41.0	44.0	0
10.45 a.m.	41.0	44.5	0
11.00 a.m.	41.0	45.0	0
11.15 a.m.	39.0	45.0	0
11.30 a.m.	37.5	46.0	0
11.45 a.m.	36.0	47.0	0
12.00 noon	35.0	48.0	0
12.15 p.m.	35.0	49.0	0
12.30 p.m.	33.0	50.5	3
12.45 p.m.	32.0	53.0	7
1.00 p.m.	31.0	55.0	0
1.15 p.m.	30.0	53.0	0

The results are summarized in Table VI and illustrated by the curve in Fig. 5. Beetles exposed to 48°C. were thrown into a state of heat stupor after 150 minutes. At a slightly higher temperature, i.e. 50°C., the time taken by the beetles to show this phenomenon was much reduced to 58 minutes. At still higher temperatures, e.g. 52, 54, 56, 58, 61 and 62°C., heat stupor was recorded after 32, 10, 8, 6.5, 4 and 4 minutes, respectively.

TABLE VI

Effect of high temperature on Adesmia (*heat stupor*) *at* 35% *R.H.*

Temp. in °C.	48	50	52	54	56	57	58	61	62
Time in min.	150	48	32	10	8	6.5	6	4	4

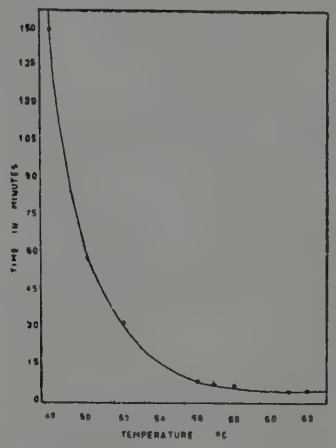

FIG. 5: Graph showing the effect of temperature on heat stupor of the adult.

V. MATING AND OVIPOSITION

Copulation of adult *Adesmia* usually occurs in the field in February. During copulation the male approaches the female, mounts on her back and holds to her abdomen by the fore and the middle legs. The male then produces its aedeagus and introduces it into the female genital opening. Usually, the female remains motionless during coitus; but when disturbed it walks carrying the male on her back and sometimes helping her by walking with his hind legs while still holding to her. Copulation usually lasts, on an average, about 25 minutes but a maximum time of 90 minutes was also recorded. Copulation might occur more than once.

Accidentally in the field, a male *A. bicarinata* may climb over the back of a female *Adesmia montana* or a male *Adesmia montana* may climb over a female *Adesmia bicarinata*. However, no copulation in these cases was seen to occur between the two different species.

Egg laying in *A. bicarinata* in the wadies started in February. Eggs were deposited singly close to each other under shrubs. A maximum of 20 eggs were deposited by one female per day. It was, however, not possible to determine the

total number of eggs deposited by a single female as those collected from the field were of unknown age.

During oviposition the female protrudes her ovipositor and pushes it into the ground in a vertical position. When the egg is deposited, just below the soil surface, the female draws its ovipositor and then covers the egg by a thin layer of sand which it pushes by its hind legs.

It seems that fine dry soil is necessary to stimulate oviposition in *Adesmia bicarinata*. This was indicated experimentally by placing a number of males and females in ajar with some stones at the bottom. In spite of the occurrence of copulation no eggs were deposited. When the beetles were transferred to jars with fine dry sand at the bottom they soon deposited their eggs. Similarly, eggs were deposited on clay or silt.

Darkness seems to be also an inhibiting factor for egg deposition. Paired beetles kept in the dark for various periods did not deposit any eggs unless they were transferred to direct light.

The egg is relatively large, oval in shape and with an average length of 3.8 mm. and an average width of 1.4 mm. Both ends are round but with a slightly broader anterior pole. The chorion is leathery in texture and without any sculptures. Sand particles very often are stuck to its surface.

The egg is white in colour and changes into pale yellow as the embryo inside advances in development. The newly formed larva can be clearly seen through the transparent chorion shortly before hatching.

Incubation period

Owing to the technical difficulties it was almost impossible to determine the incubation period of the egg under natural field conditions. This was compensated by laboratory breedings under fluctuating and controlled temperature and humidity conditions, and correlating the results with physical conditions to which the eggs are exposed in nature.

The mean temperature of the laboratory (where breeding mostly took place) during the first half of May, ranged between 29.5°C. as a maximum and 24°C. as a minimum. The relative humidity on the contrary, fluctuated between a maximum of 92% recorded at night and a minimum of 25% recorded by day.

The duration of the incubation period of 30 eggs under these temperatures and humidities averaged 9 days with a maximum duration of 11 days and a minimum of 8 days.

The effect of constant temperatures and humidities (Table VII) showed that the former, under the various humidities seem to be the limiting factor in the duration of the egg stage. Under four constant temperatures, i.e. 24, 28, 32 and 36°C., increase in temperature considerably decreased the duration of the incubation period

TABLE VII

Incubation period under controlled conditions, in days

Temperature in °C.	24			28			32			36			40		
R.H.%	mx.	mn.	Average	mx.	mn.	Average	mx.	mn.	Average	mx.	mn.	Average	mx.	mn.	Average
30	32	23	26.0±0.21	16	10	12.5±0.08	11	6	8.0±0.05	8	6	6.7±0.03	11	5	6.0±0.11
50	33	24	26.5±0.06	17	9	12.5±0.25	12	6	8.0±0.18	10	6	6.4±0.50	—	—	—
70	28	24	26.5±0.04	17	9	12.9±0.04	11	6	8.1±0.30	9	6	7.0±0.02	—	—	—
90	28	21	25.5±0.48	19	11	13.2±0.06	12	6	8.6±0.12	11	6	7.1±0.42	—	—	—

(Table VII and Fig. 6). This decrease was not proportional to the increase of the temperature because whereas the time necessary for the egg to hatch at 24°C. was 26.5 days on an average, at 28°C. it was 12-13 days, at 32°C. about 8 days and at 36°C. it was 6.4-7 days.

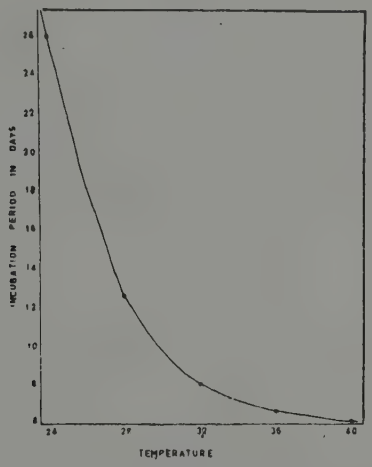

FIG. 6: Incubation period at different temperatures and at 30% R.H.

Change of humidity, however, seems to play a non-significant rôle especially at the lower temperatures where no effect was noticeable on the duration of the egg stage. However, at 36°C., medium and high humidities, i.e. 70 and 90%, seemed to prolong the duration of the egg stage but very slightly (Table VII).

At 40°C. and 30% R.H. the incubation period lasted 6 days on an average similar to 36°C., indicating that rise in temperature from 36-40°C., seems to be of no appreciable effect, at the low humidity.

Eggs incubated at 44°C. and 30, 50, 70 or 90% R.H. failed to hatch and shrivelled after a very short period.

Effect of short exposure of eggs to high temperature

In the field, eggs normally deposited under shrubs were exposed for various periods to the direct heat of the sun passing through the branches of the shrub. The effect of short exposure of eggs to high temperatures on the percentage hatching was tested in the laboratory.

Six groups of eggs each composed of 10, were exposed for various periods, with a minimum of 30 minutes and a maximum of 8 hours, to a high temperature 48°C. and 30% R.H. These eggs were then incubated at 30°C. and 30% R.H. Table VIII shows the results and indicates that a 100% hatching was obtained

with eggs exposed to the high temperature for 30 minutes or one hour. However, when the period of the exposure was increased to 2 hours only 60% of the eggs hatched. On the other hand, eggs subjected to this high temperature for more than two hours failed to hatch, and shrivelled.

TABLE VIII

Effect of short exposure of eggs to high temperature

Number of eggs	Period of exposure in hours	Number hatching	%
10	0.5	10	100
10	1.0	10	100
10	2.0	6	60
10	4.0	0	0
10	6.0	0	0
10	8.0	0	0

VI. THE LARVAL STAGES

The larvae live in the soil around the roots of the desert plants on which they possibly feed. They are commonly found in different soil substrata ranging from 5-60 cm. deep from the surface. Mostly they occur around the roots of *Zilla spinosa* which are odoriferous, well developed and extend deep into the soil.

The first stage larva (Fig. 7) leaves the egg through the wide anterior end. On hatching it is first white in colour but it soon changes into pale yellow. The

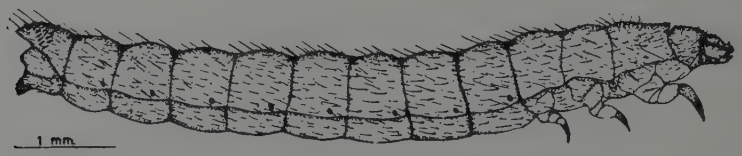

FIG. 7: First instar larva of *Adesmia bicarinata* Klug, (lateral view).

larva is subterranean; immediately after leaving the egg, it bores into the soil using mainly its anterior legs for digging. During the first stage, the larva does not take any food. It measures 7.1 mm. in length as an average and the width of its head capsule is 0.7 mm.

Under controlled conditions, the first larval stage lasted an average duration of 2.7 days at a mean temperature of 32°C. and a mean relative humidity of 70%.

Difficulties were experienced in the laboratory in obtaining all the larval transformations as a result of failure of simulating the natural desert environment under laboratory conditions. Therefore, it may be pointed out, however, that the

number of the larval instars is likely to exceed seven as the seventh larval instar seemed remote from the full grown stage.

The durations of the larval stages obtained in the laboratory are included in Table IX, and the difference in length of the body and the width of the head of the larval instars are given in Table X.

TABLE IX

Duration of various instar larvae at 32 C. and 70% R.H.

Larval instar	Number	Duration in days		
		Max.	Min.	Mean
First	50	3	2	2.7 ± 0.07
Second	14	14	8	11.0 ± 0.55
Third	11	20	8	13.3 ± 1.16
Fourth	5	14	12	13.0 ± 0.51
Fifth	4	19	13	12.0 ± 0.71
Sixth	1	00	00	12.0

TABLE X

Measurements in mm. of the length and the head width of the different larval stages.

Larval stage	Number measured	Body length in mm.			Head width in mm.		
		Max.	Min.	Aver.	Max.	Min.	average
First	20	7.8	6.6	7.1	0.7	0.7	0.7
Second ..	20	8.5	7.0	8.0	0.9	0.8	0.9
Third	15	14.0	10.0	12.5	1.2	1.0	1.1
Fourth ...	10	18.0	15.0	16.5	1.5	1.3	1.4
Fifth	3	21.0	18.0	19.0	1.7	1.5	1.6
Sixth	2	28.0	23.0	25.5	2.0	1.9	2.0
Seventh ..	1	00.0	00.0	30.0	0.0	0.0	2.2

The second instar is but very slightly longer than the first instar. The body had an average length of 8 mm. and an average head width of 0.9 mm.

At the constant temperature 32°C. and 70% R.H., the second instar larva on an average took about 11 days before it moulted to the next instar. A maximum duration of 14 days and a minimum duration of 8 days were recorded. During this stage of larval development, cannibalism occurs frequently, the larvae attacking each other in the abdominal regions.

The third instar larva had a mean body length of 12.5 mm. and a mean head width of 1.1 mm. The duration of this stage was 13.3 days on an average which was relatively longer than the second instar larva. Maximum duration of this instar was 20 days and the minimum duration was 8 days.

The fourth stage larva is about twice the body length of the second instar measuring on an average 16.5 mm., and has an average head width 1.4 mm. The mean duration of the life of this stage was 13 days with a maximum of 14 days and a minimum of 12 days.

The fifth and sixth instars differed also in their body length and their head width. The first had a mean body length of 19 mm. while the second had a body length of 25.5 mm. The mean head width of both instars was 1.6 mm. and 2 mm., respectively. Both instar larvae, however, were found to have the same length of life, 12 days on an average under the same temperature and humidity conditions, i.e. 32°C. and 70% R.H. (Table IX).

Only one larva from the sixth instar successfully moulted to the seventh instar. This larva lived for about 20 days before it died. It had a body length of 30 mm. and a head width of 2.2 mm.

VII. ADAPTATION TO DESERT LIFE

Adesmia bicarinata Klug is a typical desert insect that feeds on plants growing in the desert, either fresh or dry. Even *Zygophyllum* which is inedible to most desert animals because of its high salinity, is eagerly devoured by *Adesmia*. The beetle also eats living larvae and occasionally human excrement. Thus, it seems that the insect gets on well with the possible sources of food available in the desert and it can also endure a relatively long period of starvation. This may be a kind of adaptation to life in the desert under adverse conditions.

Adesmia possesses a hard and thick body cuticle which may help in protecting it from being crushed, attacked or swallowed by other animals (BUXTON, 1923). The fore-wings or elytra are immovable and firmly soldered to the sides of the abdomen leaving a space above the abdominal terga, the sub-elytral space, that usually contains fine droplets of water and its temperature is commonly lower than that of the desert surface during hot days (BUXTON, 1924). The air used for respiration passes first through the sub-elytral space that has a relatively low temperature, and thus it is possibly cooled and moistened before entering the spiracles.

The hind-wings are completely absent and the dorsum is convex. This is of great importance during windy weather. Insects with hind-wings are blown by wind for long distances and in this way they may perish (BUXTON, 1923). According to this author, the atrophication of the hind-wings may be of some adaptive significance to life in the desert.

The adult beetle lives on the soil while its immature forms are subterranean. The eggs are deposited under the shrubs in the wadies where the temperature is lower during mid-day and slightly warmer at night. Most of the eggs are not affected by the heat of the sun rays. Also, they sustain relatively high temperature for short periods (short exposure) and as low a temperature as 5°C. without being injured. The

female deposits the eggs singly, and somewhat far from each other, leaving no chance for the emerging larvae to compete for food or place. Also, the relatively great number of eggs produced by a single female may be a precautionary measure against the severe desert conditions endangering the vitality of the eggs or killing a high percentage of them.

The first stage larva leaves the egg that is deposited just below the soil surface and bores directly into lower substrata. During this stage, the larva does not take any food, probably to be engaged first in reaching its normal habitat and food supply around plant roots.

The second stage larvae on the other hand, are active feeders, sometimes devouring each other. In its micro-climate, the larva is not subject to severe fluctuations of temperature and humidity which occur on the surface. Such more or less stable climatic conditions together with the immediate availability of food and water provided by succulent fruits of desert plants, mostly ensured the successful development of the larva in its environment.

The adult beetle disappears completely and possibly perishes throughout the summer and early spring (late May to early October), a period during which the soil surface temperature is remarkably high (e.g. 56°C. in the sun and 42°C. in the shade), untolerated by the beetle and mostly detrimental to its life. The larvae, during these hostile months of the year, undergo successfully their development in their safe abodes and complete the life-cycle by the end of October when adult beetles emerge and start their life in the open desert. Usually, they do not wander far away from their hiding places. When unfavourable conditions set in, or when alarmed, the beetles immediately hurry to the nearest shelter in a crevice or under a dense spiny shrub. Mostly the two sexes are near to each other and copulation is commonly repeated daily.

The beetles are naturally hidden under shrubs or in holes during cold weather and at night. They do not commonly leave their places except when the temperature rises above 15°C. or even 20°C. They are always seen wandering on the soil surface when its temperature ranges between 20 and 45°C., but at higher temperatures, the beetles soon choose for their stay other cooler micro-climates, mainly under shrubs. Its great sensitivity is an important factor in their resistance to hot xerophytic atmosphere. No doubt that the humidity existing under any living plant is higher, and the temperature is lower than those prevailing on the open desert surface, a case that minimises the power of evaporation from the insect body and thus the insect maintains its water balance intact.

The beetles show a marked resistance to high temperature; thus, they can withstand 48, 52, 56 and 61°C. for 150, 32, 8 and 4 minutes, respectively. This is not beyond expectancy as the insect in its natural environment usually encounters as high a temperature as 50 or 60°C. in the open desert, though under such conditions, however, the insect normally seeks shelter in cooler atmosphere under shrubs and other patchy vegetation in the desert.

From the foregoing it may be said that *Adesmia bicarinata* is possibly adapted to desert conditions in several ways. Thus:

(1) The curvature of the abdomen lessens the absorbed heat from the incident sun rays and accordingly the temperature does not rise very high.

(2) The fore-wings or elytra are heavily chitinized and firmly soldered to the abdomen possibly protecting such a conspicuously black diurnal insect against enemies, and enclosing the sub-elytral space which is usually cooler than the hot surface of the sand. The hind-wings being atrophied, and the fore-wings being firmly soldered to the abdomen may protect the insect against the danger of being blown off during stormy weather.

(3) The beetle makes use of all possible sources of food encountered in the desert, e.g. all parts of plants, dried or fresh, living larvae and possibly human excrement, and so it unlikely suffers shortage of food although it can withstand starvation for a long time (about 15 days).

(4) The insect resists prolonged periods of drought even if it is previously desiccated.

(5) *Adesmia* endures high temperatures. It is uninjured if it is subjected to 48, 54, or 60°C. for 150, 10 and 4 minutes, respectively.

(6) The life-cycle is comparatively long (probably not less than one year). The larval and pupal development last more than 5 months and no emergence of the adult takes place during the very hot season which is hostile to the adult insect.

(7) The eggs are laid daily, singly, from 15-20 eggs per day during the breeding season. They develop successfully under relatively high temperature such as 40°C. and are unaffected if they are exposed to higher (e.g. 44 or even 48°C.), or lower (e.g. 5°C.) temperatures for short periods. However, the greatest number of eggs is deposited during the cold season (February-April) and in the sub-soil where the temperature is less fluctuated and more favourable.

VIII. SUMMARY

Adesmia bicarinata Klug, a "wingless" Tenebrionid beetle, is a dominant member of the insect fauna of the Egyptian deserts; particularly abundant in Wadi Hof and Wadi Digla south-east of Cairo. It is large in size (11-20 mm. in length), black in colour and frequently seen wandering about on sand by day taking no refuge from the mid-day sun but retreating under stones or shrubs at night or during adverse conditions.

The results of the studies on the bionomics of this insect may be summarised as follows:

(1) THE NATURAL ENVIRONMENT: This insect dominates in several wadies or valleys which dissect a vast extensive area in the form of an elevated plateau of the

middle Eocene limestone south-east of Cairo. Most of the field studies were conducted in Wadi Hof and Wadi Digla. The fauna and flora of the wadies are better developed than those of the open desert.

As to the climatic conditions prevailing in these wadies it was found that:

(*a*) The temperature shows great fluctuations between localities close to each other. The mean monthly air, shade and soil temperatures increased gradually from low values in February (e.g. 18.7, 21.8 and 27°C., respectively) to relatively high values in May (e.g. 33, 34.6 and 48.1°C., respectively). The air and shrub shade temperatures were nearly equal and were almost in all months (especially in the hot season) considerably below the soil surface temperature at any hour of the day.

The air and shrub shade temperatures tended to show very slow and gradual variation in their daily temperature change while the soil surface temperature tended to heat up and cool down rather rapidly.

(*b*) The daily relative humidity similarly showed marked fluctuations; thus it was 58% at 8 a.m. and dropped to 25% at 11 a.m. in August, but the mean relative humidity during the whole year shows the least fluctuations within the various months. It was 54.4% in March compared with 32.4% in August (1954-1955).

(*c*) The rain is scanty in the wadies. The total yearly rain-fall does not exceed 25 mm. falling mainly during the winter months.

(2) Habits: The beetles always hide under shrubs or in crevices during periods of inactivity, at night and on the onset of unfavourable conditions. They are very active during February, March, April and May (period of inactivity) and often seen wandering about on the sand by day. On windy weather, the beetles often bury their heads and prothorax in the soil. They hardly migrate far from their sheltering places.

The beetles start their daily activity when the prevailing temperature is 20-45°C. and hide under shrubs at higher temperatures (above 45°C.).

Beetles kept in bare desert without shade and given ample food all died after 5 days. Those kept among *Zilla spinosa* and *Anabasis setifera* plants, rocks and patchy vegetation in varying degrees of density to provide shade, lived for longer periods, sometimes reaching about 30 days. Therefore, objects that provide suitable shade in the desert, i.e. giving a range of different temperatures seem to be of importance in reducing the rate of mortality of the beetles.

(3) Relative abundance: The adults start to appear in small numbers in late October. Their population gradually increases and the peak of abundance occurs in March. By the end of May the beetles disappear completely and only their dead bodies are found beneath the shrubs and other stituations. The disappearance of the beetles may be correlated with the high mortality due to excessive heat during the summer. During the hot season the life cycle is continued by the larval and pupal stages in the soil.

(4) Food and feeding habits: The insect is mainly vegetarian, sometimes, however, feeding on living larvae; in one case the beetles were seen to eat human excrement. It shows a marked resistance to starvation especially in the case of the female (starvation period reaching about 19 days).

(5) Heat stupor and resistance to high temperature: The beetles were unaffected when they were left under gradually rising temperature of the soil surface and they died when it reached 50-53°C. (R.H. about 32%). The same conclusion was arrived at in the laboratory. When the beetles were left at high temperatures such as 48, 52, 58 and 62°C., they fell into a state of heat stupor after 150, 32, 6 and 4 minutes, respectively.

(6) It was found that copulation usually occurs in the field in February. It lasts for about 25 minutes on an average but this time may be prolonged to about 90 minutes.

Egg-laying starts in February in the sub-soil under shrubs. A maximum number of 20 eggs is laid by one female per day. It seems that fine soil and light are necessary for stimulating oviposition.

The egg is leathery in texture, white in colour, oval in shape and large in size (3.8 mm. long and 1.4 mm. broad).

Under laboratory conditions, the incubation period lasted from 8 to 11 days, with an average of 9 days. This period varied at different temperatures. Thus at 24, 32 and 40°C. and at 30% R.H., the incubation period lasted for about 26.5, 8 and 6 days, respectively.

The eggs were unaffected when subjected to 48°C. for one hour and 40% failed to hatch when they were left for 2 hours at such temperature.

(7) The larval instars are subterranean, living around the roots of the desert plants, whitish in colour and campodeiform. They are always found around the roots of the desert plants 5-60 cm. deep in the soil. The first larva does not take food, while the second and the following larvae are active feeders devouring the roots around which they live.

The larval durations of the first, second, third, fourth and fifth stages were about 2.7, 11.0, 13.3, 13.0 and 12.0 days, respectively, at 32°C. and 70% R.H.

The first stage larva measures 7.1 mm. in length while the seventh measures 30 mm.

(8) Adaptation to desert life: The possible adaptive modifications in relation to desert life have been discussed and summarised in Chapter VII.

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HISTOLOGY OF THE ALIMENTARY CANAL OF *ACRIDA PELLUCIDA* KLUG

[*Orthoptera* : *Acrididae*]

(with 21 Text-Figures)

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INTRODUCTION

The histological studies of the alimentary tract of the common species of locusts and grasshoppers have received a good deal of attention from recent workers. Among the notable articles published in this field we may mention the work of HODGE on the histology of the various parts of the alimentary canal of *Melanoplus differentialis* (1936), *Locusta migratoria* (1939) and *Radinotatum carinatum* (1940). TIETZ (1923) also described the histology of the alimentary canal in *Dissosteira carolina*, and CHAUVIN (1938) did the same on *Schistocerca gregaria*.

The review of literature reveals that no histological studies seem to have been made by previous workers on the digestive tract of *Acrida*. The present work, therefore, deals with the histology of all parts of the alimentary canal of this insect, and the different structures are, as far as possible, compared with those of other common species.

The epithelial lining of the alimentary canal rests on a thin basement membrane. Cells of this epithelium are generally of large size, being mainly cuboidal in the stomodaeum, columnar in the mesenteron and most of the proctodaeum. In the stomodaeum and proctodaeum the epithelium is usually thrown into folds, and lined internally by a cuticular intima of variable thickness. The latter may be smooth, pitted or covered with setae. In the mesenteron the epithelial lining is unfolded and possesses a fairly broad striated inner border. The epithelial cells of the

stomodaeum are charged with granules of a dark brown pigment which gives the whole organ a brownish appearance that stops abruptly at its posterior end. Similar, but lighter, pigmentation is to be found in the anterior part of the proctodaeum, but soon disappears posteriorly.

The walls of the alimentary canal are invested in a muscular coat consisting of one or more layers of circular and longitudinal fibres. The circular muscles form a complete ring around the wall, or may sometimes be interrupted in some parts. The longitudinal muscles are generally aggregated in bundles and may be branched inside the epithelial folds.

The peritoneal membrane ensheathing the alimentary canal when present is very thin, but it is generally absent in most parts.

THE STOMODAEUM

The epithelial cells are more or less cuboidal with rounded large nuclei. In most parts of the fore-gut they are arranged in one layer. Cell boundaries are somewhat distinct in some regions, yet they are generally obscured by the densely aggregated granules of the brown pigment.

The intima is relatively thick. It may be smooth, pitted, or covered with setae, and is thrown into numerous folds.

The muscularis is well developed and is usually separated from the stomodaeal wall by a space filled with connective tissue. The circular muscles are external in position to the longitudinal muscles.

The pharynx

The pharynx of *Acrida* is a relatively short muscular thick-walled tube covered internally by a well developed chitinous coat (Fig. 1,i) thrown into 6 voluminous longitudinal folds, more or less occupying the lumen of the organ. The crests of these folds are more heavily sclerotised than the intervening intima. Numerous posteriorly-directed long setae (se) densely cover the surface of the pharyngeal intima, mainly on the folds, though very few setae may be seen on the intervening spaces. In *Locusta migratoria* (HODGE, 1939), *Leptysma marginicollis* and *Opshomala vitreipennis* (HODGE, 1943) the pharyngeal intima is thrown into longitudinal folds but devoid of any spines or teeth. In *Melanoplus differentialis* (HODGE, 1936) numerous spines are found but there are no folds. In *Radenotatum carinatum* (HODGE, 1940) neither spines nor folds are present.

Below the chitinous layer just mentioned, the wall of the pharynx (Fig. 2) shows from inward outwards:

(*a*) A layer of cuboidal epithelial cells (ep) beneath the folds, but become considerably flattened inbetween them. These cells have large nuclei (nu), and are heavily charged with brown pigment granules which obscure their details. In some parts the pigment is relatively lighter and thence the cell walls may be somewhat distinct. The nuclei are generally circular or nearly so in section, and heavily loaded with granules. In some parts, below the folds, some of the cuboidal cells elongate and become more columnar in appearance. In *Dissosteira carolina* (TIETZ, 1923) the epithelial lining of the corresponding part consists of columnar cells with very indistinct cell walls.

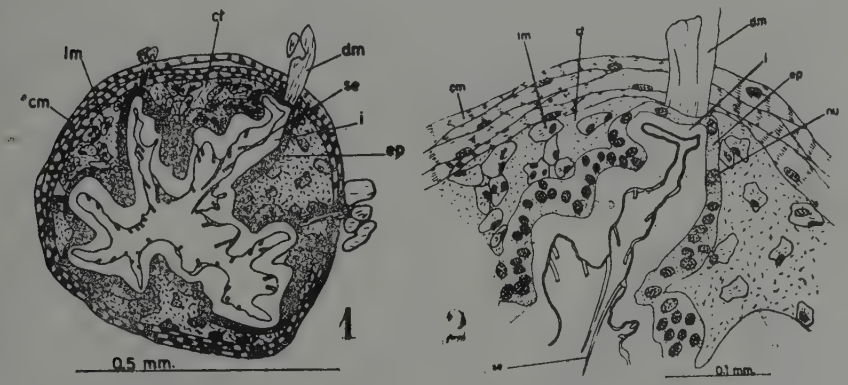


FIG. 1: Transverse section through the pharynx (cm, circular muscles; ct, connective tissue; dm, dilator muscles; ep, epithelium; i, intima; lm, longitudinal muscles; se, setae). — FIG. 2: Portion of transverse section through the pharynx (nu, nucleus; other lettering as in Figure 1).

(*b*) A layer of connective tissue (ct) which is well developed in the central portions of the elevations where it forms the "core". Under the furrows, however, it is very scanty or even absent.

(*c*) Bands of striated longitudinal muscles (lm) which are scattered amongst the connective tissue directly below the folds, though some bands may be found between them.

(*d*) The outermost layer consists of striated circular muscles (cm) which are fairly thick (2-4 fibres) and well developed.

The dilator muscles (dm) are thick and oblique in position, penetrating through the muscle coating of the pharyngeal wall to get insertion on the cuticular intima inbetween the epithelial cells.

The oesophagus

The oesophagus (Fig. 3) is a somewhat ovoid tube that arises as a sudden dilatation of the pharynx, and leads posteriorly into the crop from which it is almost

indistinguishable externally. Internally, the oesophageal wall is covered by a well developed chitinous coat (i) produced into numerous obliquely transverse folds over the lateral walls of the tract. They are more strongly oblique cephalad but become more inclined to the vertical direction (in relation with the longitudinal axis of the body) towards the posterior end of the oesophagus. This condition is similar to that described for *Leptysma*, but in *Opshomala* the folds are diagonal and nearly parallel (HODGE, 1943).

The folds are not high, and so the organ has a fairly wide lumen. The most anterior and posterior folds are merely a series of short disconnected pads, the more so in the posterior region.

On the ventral mid-line of the oesophagus the pattern of the intima is different from that on the sides. There is a narrow ventral strip of discontinuous irregular longitudinal folds, 4-5 in number. On the dorsal side of the anterior part of the oesophagus the intima is thrown into few transverse folds that merge gradually into the oblique lateral folds.

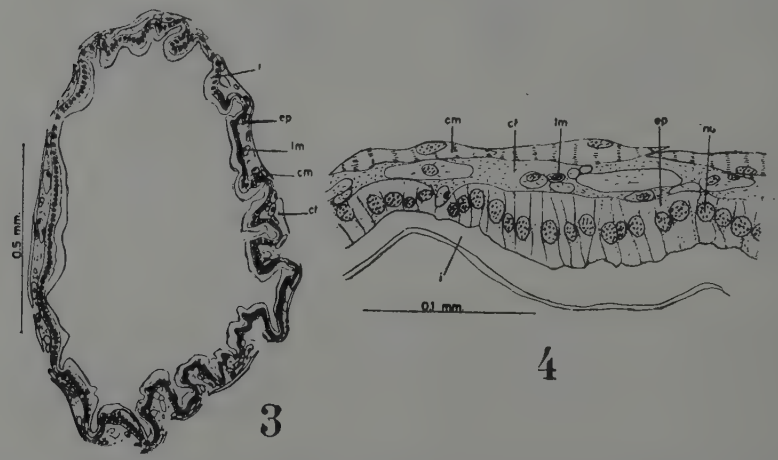


FIG. 3: Transverse section through the anterior region of the oesophagus (lettering as in Figure 1). — FIG. 4: Portion of transverse section through the anterior region of the oesophagus (lettering as in Figure 2).

The intima of the oesophagus carries heavy, conical, slightly curved, minute spines distributed along the tops of the folds in rather regular rows, the broader elevations bearing more numerous rows. The furrows between the folds are devoid of such spines. These spines are more densely scattered in the anterior region of the

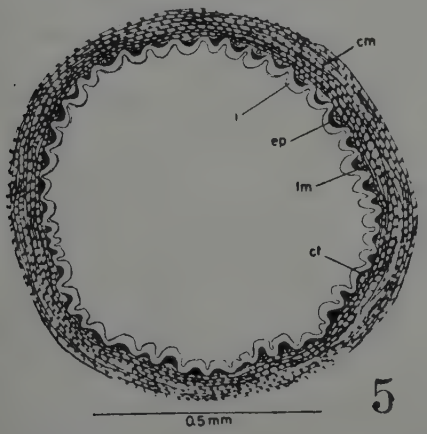
oesophagus, but become less numerous towards the posterior end. In both *Leptysma* and *Opshomala* the oesophageal intima is spined throughout, while that of *Radinotatum* is devoid of any spines. In *Dissosteira* the corresponding region is provided with spines except in its anterior part.

The histological elements in the oesophagus are the same as in the pharynx. The same layers are present and are in the same order (Fig. 4). However, the folds are here more numerous and less prominent. Besides this, the oesophagus is coated with a thin sheath of circular muscles (1-2 fibres thick). On the posterior two thirds of the oesophagus the circular fibres have the form of continuous rings encircling the organ. On the anterior third, on the other hand, the ring muscles are interrupted in many points. Also the longitudinal fibres are here less than in the pharynx, and the "cores" of the folds are mainly filled with connective tissue. In the posterior part, these fibres become more numerous again.

The epithelial cells of the oesophagus are of the cuboidal type, though the columnar type is not infrequent, especially in the folds, and all the cells are heavily charged with pigment granules which, though obscuring their nature, yet the cell walls are here more distinct than in the pharynx.

The crop

Externally the oesophagus and crop are practically indistinguishable at the junction of both regions, since they are nearly of the same diameter. But the wall of the crop rapidly becomes thicker as it proceeds caudad and becomes more muscular. The thick-walled portion of the crop extends for about half of its length, and then the wall gradually becomes thinner for the remaining part.



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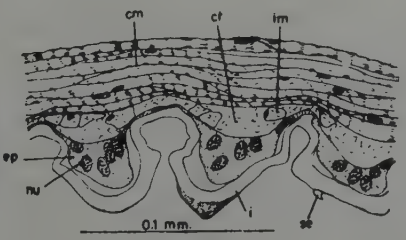

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FIG. 5: Transverse section through the anterior region of the crop (lettering as in Figure 1). — FIG. 6: Portion of transverse section through the anterior region of the crop (lettering as in Figure 2).

Internally, the intima of the crop is quite thick and presents two distinctly different patterns. In the anterior half the intima is thick, stiff and produced into a series of discontinuous folds grouped in parallel longitudinal rows, similar to the condition in *Leptysma*, *Opshomala* and *Dissosteira*. These folds, about 42 in number, are separated by furrows on which the intima is somewhat thinner (Figs. 5 and 6,i). Each fold is armed with numerous minute spines (se) scattered along its crest.

In the posterior half of the crop the intima is thinner and less stiff, and is produced into longitudinal unbroken folds that carry sparsely scattered spines which disappear completely just before the organ merges into the proventriculus. In this bare area the longitudinal folds gradually collect, by the intervening spaces being raised to the level of the folds, to form the beginning of the six broad plates of the proventriculus.

The wall of the crop (Fig. 6) consists mainly of the same elements forming that of the oesophagus. The epithelial cells are of the cuboidal type, becoming greatly flattened below the furrows. The nuclei are of relatively large size, and the cells are also charged with brown pigment, and cell boundaries are generally indistinct. The longitudinal muscles mainly occupy the space below the folds among the connective tissue while some fibres occur below the furrows. The circular muscle layer is well developed especially in the anterior half where it is of great relative thickness (6-7 fibres), yet posteriorly it becomes thinner (2 fibres), but still forming a continuous uninterrupted ring.

The proventriculus

This is a short poorly developed region representing the last division of the stomodaeum. The location of this portion of the tract is indicated externally by a slight constriction just anterior to the point of attachment of the gastric caeca. In a longitudinal section (Fig. 7), this part projects into the anterior region of the ventriculus reaching just past the openings of the gastric caeca and constitutes the stomodaeal invagination or cardiac valve. The ventriculus, therefore, has a larger diameter to allow for this intrusion, and a sort of shallow groove is formed around the tract at the beginning of the ventriculus for the formation of the peritrophic membrane. Such groove is not found in *Locusta migratoria* (HODGE, 1939).

The wall of the proventriculus (Figs. 8 and 9), though thin, is thicker than in the posterior region of the crop. Internally, similar to other Acridids, the intima is produced into 6 longitudinal low proventricular plates that slightly reduce the lumen of the organ. These are V-shaped flat islands with the broader end lying anteriorly, and with the notches that give them the V-shaped appearance extending about half their length. They are simply rounded at their narrow posterior ends where they all end on the rim of the wide round orifice into the ventriculus. These plates carry numerous minute conical spines (se) which are densely scattered anteriorly, while they are sparse posteriorly. Such spines are recorded in *Leptysma*,

Radinotatum and *Dissosteira*, while in *Opshomala* and *Locusta* no spines occur, but the proventricular plates in *Opshomala* are tickly covered with minute rounded tubercles. Between each two plates extend 3 small longitudinal folds which are continuations of the folds of the crop. These small folds also carry but fewer minute spines.

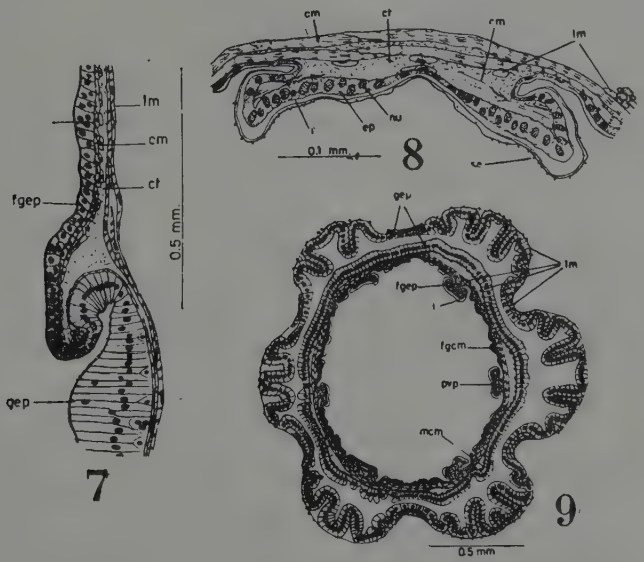

FIG. 7: Longitudinal section through the stomodaeal valve (fgep, foregut epithelium; gep, midgut epithelium; other lettering as in Figure 1).—FIG. 8: Portion of transverse section through the proventriculus (rm, retractor muscles; other lettering as in Figure 1). — FIG. 9: Transverse section through the stomodaeal valve, anteriorly (fgcm, foregut circular muscles; fgep, foregut epithelium; gep, midgut epithelium; i, intima; lm, longitudinal muscles; mcm, midgut circular muscles; pvp, epithelium; proventricular plate).

Below the intima (i) is an epithelial layer (ep) of cuboidal cells with large rounded nuclei (nu), indistinct boundaries, and charged with pigment granules. Below the epithelium is a small amount of connective tissue followed by a thick band of circular muscles (2-3 fibres). The bands of longitudinal muscles forming the outer coat of the stomach, continue anteriorly to the point of attachment of the gastric caeca. Here some divide and go around on either side of the caeca, uniting on the other side where they form an incomplete outer coat of the proventriculus. This coat runs for a very short distance and ends just below the point where the V-shaped projections begin. The remaining longitudinal fibres may form the outer coat of the caeca, and few fibres are present in the "cores" of the folds. Also, delicate retractor muscles (rm) are present within the proventricular plates. They originate

either on the surface of the intima on one side of the plate, or as branches of longitudinal or circular muscle fibres. They are inserted upon the inner surface of the intima, between the epithelial cells.

THE MESENTERON

The mesenteron, or mid-gut, comprises the gastric caeca and the ventriculus (stomach). It is a relatively short tubular structure limited externally by the origin of the mesenteric caeca anteriorly and the bases of the Malpighian tubes posteriorly. Actually the mesenteron begins on the outer fold of the stomodaeal invagination.

The muscularis of the mid gut is weakly developed and consists of delicate longitudinal muscles to the outside and slender circular muscles to the inside.

The mesenteric epithelium forms a thick layer composed of relatively large columnar cells with distinct boundaries and elongate oval nuclei, and velvety appearance.

The ventriculus

This is a simple straight tube, broadly oval or nearly cylindrical in cross section (Fig. 10). It forms about 11% of the length of the whole tract. Such a short ventriculus is recognised in some species as *Opshomala* (11%), *Locusta* (14%) and *Dissosteira* (16%), while it is longer in others as *Leptysma* (24%) *Radinotatum* (25%), *Melanoplus differentialis* (24%).

Although the gastric caeca are outgrowths of the stomach, the latter shows histological characters peculiar to itself. Here the muscular coat is more developed, being formed of two layers. The outermost is a fine layer represented by some separate bands of longitudinal muscles. Next comes a thin, continuous layer of circular muscles which are faintly striated. Permeating the rest of the wall of the stomach are few strands of connective tissue in which lie embedded a layer of unfolded gastric epithelium composed of two different types of cells: the digestive and the regenerative epithelium.

The digestive epithelium (Figs. 10 and 11, gep) is composed of fairly elongate columnar cells that lie in a regular row perpendicular to the basement membrane (bm), with their boundaries distinct and almost parallel to one another. Their inner walls exhibit a fairly broad striated border (sb), as in other grasshoppers, giving the wall a velvety appearance. The digestive epithelium starts well within the groove for the formation of the peritrophic membrane, and extends caudad to the proctodacal valve. In these cells the nuclei are voluminous and generally central in position, though more inclined towards the basal region. The nuclei of the gastric

epithelium contain coarse granules and range from circular to oval in section. Ordinarily they are oval with the long axis parallel with that of the cell.

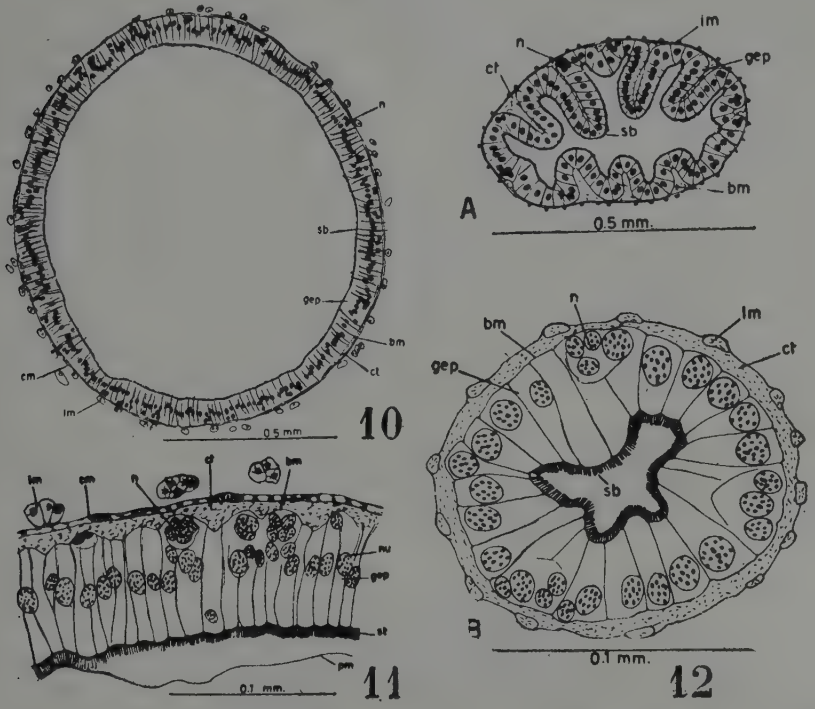

FIG. 10: Transverse section through the ventriculus (bm, basement membrane; gep, digestve epithelium; n, nidus ; sb, striated border; other lettering as in Figure 1). — FIG. 11: Portion of transverse section through the ventriculus (pm, peritrophic membrane; other lettering as in Figure 10). — FIG. 12: Transverse section through the mesenteric caecum (A, anterior lobe; B, posterior pouch; lettering as in Figure 10).

Inbetween the digestive epithelial cells are islands or nests of nuclei (nidi) (n) which form the second type of cells and which are centres of regeneration, replacing those cells which are no longer functional. These nests, as is usual in grasshoppers, are to be found scattered throughout the mid gut in both the ventriculus and caeca, generally located basally.

The gastric caeca

The caeca open into the stomach broadly with large apertures which are not confluent, but are so arranged that a line drawn through them would form a circle

around the anterior end of the ventriculus (Fig. 9). Food readily enters the caeca and therefore they are variable in size due to variable distension. In a cross section (Fig. 12), the caeca are somewhat flattened and ellipsoidal in shape.

Each caecum is covered externally by a poorly developed thin muscularis. The epithelial lining in both the anterior and posterior pouches of the caecum differ both in structure and arrangement. In the anterior lobe (Fig. 12A), beneath the muscular coat, there is a very thin layer of connective tissue, though in many places this is not evident. Inside this lies the epithelium which is thrown up into 6-10 irregular longitudinal folds with crypts inbetween. Most of these folds project so far into the lumen that they almost divide each pouch into numerous compartments. This differs from the case in *Opshomala* where no folds exist. In *Dissosteira*, on the other hand, the epithelium of the caecum is thrown into 12-13 prominent folds, and into 12-15 irregular folds in *Locusta*.

The epithelial cells are thick columnar, with distinct cell walls and large nuclei situated generally near their bases, and their free surfaces carry the striated border.

In the posterior lobe (Fig. 12B), the epithelial layer is unfolded, and the inner surface carrying the striated border is not smooth, but presents a rather undulating appearance. The cells are of variable length and the lumen is relatively small.

THE PROCTODAEUM

The hind gut extends from the bases of the Malpighian tubes to the anal aperture. Morphologically the proctodaeum is divided into 4 regions: pyloris, (pyloric valve), ileum, colon and rectum. Histologically the walls of the proctodaeum consist of a highly folded layer of epithelial cells lined internally by a relatively thin soft intima.

The change in shape and size of the epithelial cells from the mesenteron to the proctodaeum is sudden at the point demarcating both regions. Here the striated border disappears and the cuticular intima begins.

The muscularis consists of an outer longitudinal and an inner circular muscle layers.

The pyloris

This is the most anterior region of the hind intestine. It is formed by the approximation of the ventricular epithelium and the anterior extremities of the ileal folds (Fig. 13). It consists of a transverse fold which, when viewed from the inner surface, appears as a ditch, or circular gap, cut transversely in the wall of the digestive tube between the ventricular epithelium and the ileal plates.

The wall in the area of the valve is no thicker than in the adjacent area of the midgut or hindgut, though few separate discontinuous circular muscle fibres may be added at some points. The epithelial layer is here thin and thrown into numerous low folds. The epithelial cells are ranging from cuboidal in some parts to columnar in others. Nuclei are large, circular to oval in section. Cell boundaries are distinct but slightly obscured by the presence of brown pigment.

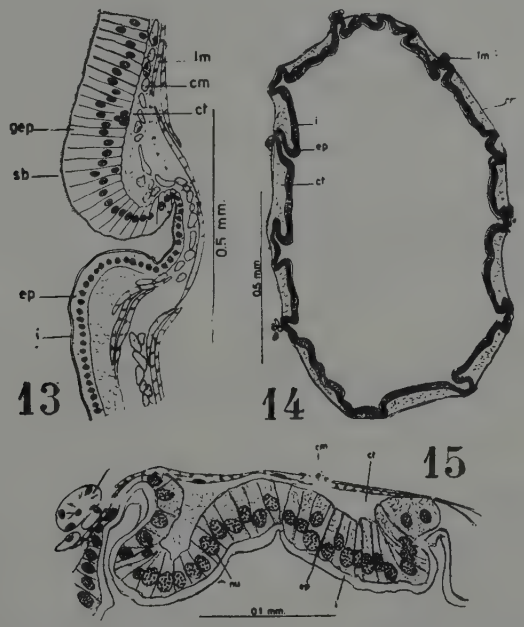

FIG. 13: Longitudinal section through the pyloric valve (ep, proctodaeal epithelium; other lettering as in Figure 7). — FIG. 14: Transverse section through the ileum (lettering as in Figure 1). — FIG. 15: Portion of transverse section through the ileum (lettering as in Figure 2).

The ileum

This is a short straight tube that tapers posteriorly. Internally the ileal wall is produced into 12 longitudinal plates that are closely approximated and may touch one another at their lateral edges (Fig. 14). These plates have rounded anterior ends and smooth surfaces, similar to the case in *Radinotatum* and *Leptysma*. They become gradually thinner and less stiff as they proceed caudad, becoming obsolete very shortly behind the pyloris. From there caudad to the colon the wall of the ileum is thrown into 12 low irregular longitudinal folds.

The intima of the ileum is thin and soft. Tubercles similar to those described for *Leptysma* (HODGE, 1943) are not observed in the ileum of *Acrida*. The epithelial

cells differ in the anterior region of the ileum from those of the posterior one. In the former the cells form a thin layer. They are columnar with large nuclei, distinct boundaries and are heavily charged with pigment granules. In the posterior part, the cells become larger forming a thicker epithelial layer, with large nuclei and sparse pigment.

The central portion of each fold, below the epithelium, is loosely filled with connective tissue (Figs. 14 and 15). Next comes a thin coat of circular muscles (1 fibre thick) outside of which are the longitudinal muscles. These latter arise as continuations of the longitudinal fibres of the mesenteron which continue on the pyloric region in the neighbourhood of the Malpighian tubes, where the fibres converge into 12 delicate bands. These bands end on the posterior edge of the pyloris where 6 new longitudinal bands take their origin to extend caudad on the wall of the ileum. They lie between each alternate pair of internal folds. The muscle fibres occur in small bundles bound together by connective tissue. In both *Leptysma* and *Opshomala* the longitudinal muscles of the ileum are grouped into 12 bands, while in *Dissosteira* and *Locusta*, similar to that in *Acrida*, they are only 6.

The colon

The colon is a short, narrow, thick-walled tube, provided with a thick flexible intima produced into 12 irregular folds (Fig. 16). In *Dissosteira* and *Opshomala*

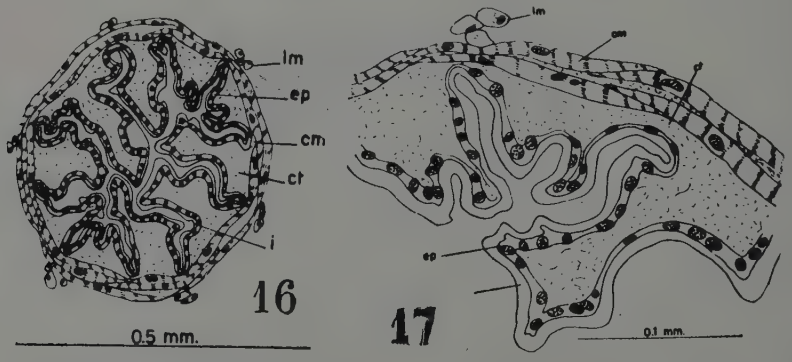

FIG. 16: Transverse section through the colon (lettering as in Figure 1). — FIG. 17: Portion of transverse section through the colon (lettering as in Figure 1).

the colon possesses 6 folds only. These folds almost touch across the lumen of the tract when the circular muscles are contracted and so the lumen is nearly occluded. Shortly before merging into the rectum, the ileal folds unite into 6 larger folds. The tops of the folds of the colon are not flat but present under the microscope a rather

undulating appearance (Fig. 17). The irregularities of contour, however, terminate just anterior to the rectal sac.

The histology of the colon is quite similar to that of the ileum, but the chitinous intima in the colon is thicker. There is also a noticeable increase in the circular muscles (3 fibres thick). The longitudinal muscles of the colon are merely continuations of the ileal muscles. The epithelium is formed of cuboidal cells that form a thin layer below the intima. The nuclei are large, rounded or ovoid; cell boundaries are indistinct and the brown pigment is absent. Large quantities of connective tissue fill the space below the epithelial folds.

The rectum

The rectum consists of an elongate ovoid rectal sac and, behind that, a terminal short narrow rectum proper. It begins just behind the last constriction of the alimentary canal that marks it off from the colon. The rectal sac is nearly as wide as the ileum. Internally, the 6 longitudinal folds of the posterior extremity of the colon continue into the rectum where they have undergone some modifications. Here the folds have been relatively reduced in height, but their width has been increased, though they become narrower again as the rectum tapers posteriorly. With an increase in the width of the folds, there is a proportional decrease in their distance apart, each elevation nearly touching its neighbours and causing the intervening furrows to be very narrow (Fig. 18).

The intima of the rectal sac is smooth and flexible. Over the rectal pads the intima is thrown up into irregular peaks quite remote from the epithelium beneath, thus there is considerable space behind the intima (Fig. 19). On the intervening spaces, however, the intima is regularly in contact with the epithelial cells. Such condition of remote intima is observed also in *Radinotatum* (HODGE, 1940) and *Schistocerca* (CHAUVIN, 1938).

The rectal sac possesses 2 types of epithelial cells. In the corners of the pads and in the spaces between them the epithelial cells are irregular (pep.). They vary considerably in size, with their nuclei irregular in shape. Cells of this type are heavily charged with brown pigment. Within the rectal pads the epithelial cells are considerably large in size (ep), columnar in shape and devoid of pigment. The nuclei are elongated ellipses in section, and are generally situated towards the bases of the cells. The 2 types of cells were also recognised in *Locusta* (HODGE, 1939) and *Radinotatum* (HODGE, 1940), yet without recording the pigment here found in the first type. The pigmented cells were, however, recorded in *Schistocerca* (CHAUVIN, 1938).

The muscularis of the rectal sac consists of a thin layer of circular muscles (1 fibre thick) outside of which lie 6 bands of longitudinal muscles. These latter bands are placed just opposite the furrows between the rectal folds and are, there

fore, external indications of their location. Between the epithelium and the muscle coating is a moderate amount of connective tissue which is more pronounced below the rectal pads.

In the rectum proper the intima has about the same thickness of that in the rectal sac, but here much harder and generally resting close to the underlying epithelium (Figs. 20 and 21). It has 6 incised major folds and a varying number of minor

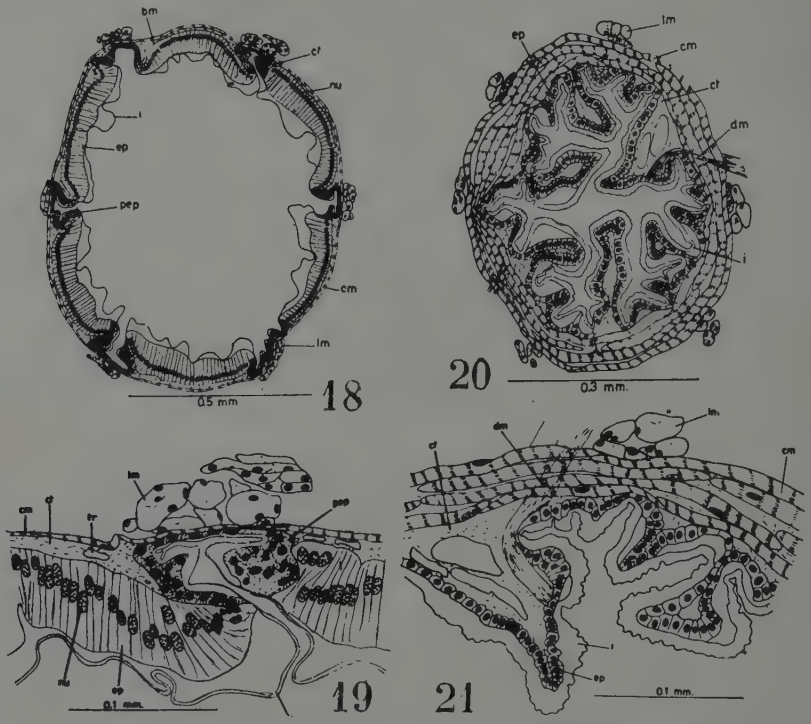

FIG. 18: Transverse section through the rectal sac (pep, pigmented epithelium; other lettering as in Figure 10). — FIG. 19: Portion of transverse section through the rectal sac (tr, trachea; other lettering as in Figure 18). — FIG. 20: Transverse section through the rectum proper (lettering as in Figure 1). — FIG. 21: Portion of transverse section through the rectum proper (lettering as in Figure 1).

folds, similar to the case in *Radinotatum*. These folds start at the caudal ends of the rectal pads. The major folds are of relatively large height that they nearly touch across the lumen of the organ. In *Leptysma* no definite folds occur, but the intima may fall into adventitious folds in varying conditions. The surface of the intima

in the rectum proper, both on the folds and the intervening spaces, is not smooth but presents a fine wavy appearance.

The epithelial cells are cuboidal in the folds, but much flattened below the furrows. The nuclei are large, irregular in shape, but generally ellipsoidal in section, and the cells contain but very little amount of brown pigment.

The musculature of the rectum proper is well developed. The 6 bands of longitudinal muscles continue also down the sides of this region. The circular muscles are fairly thick (3-4 fibres). Dilator muscles are to be observed penetrating through the wall of the rectum proper to get insertion on the intima between the epithelial cells.

In the rectum proper there is a considerable amount of connective tissue filling the spaces below the folds and binding the muscle fibres together.

SUMMARY

The important histological characters of the alimentary tract of *Acrida pellucida* may be summarized as follows:

(1) The epithelial lining of the stomodaeum is thrown into numerous folds. The intima is well developed and provided with long setae in the pharynx, while in the oesophagus and crop only minute spines are present.

(2) The stomodaeal epithelium is mainly of the cuboidal type, tending to flatten inbetween the folds. The cells are heavily charged with brown pigment.

(3) The circular muscles forming the outermost layer of the stomodaeal wall are better developed in the pharynx and the anterior part of the crop. On the oesophagus they are less developed, especially anteriorly where they are thin and discontinuous.

(4) The longitudinal muscles are well represented in all the stomodaeal regions, mainly below the folds. In the proventricular plates they branch to form the retractor muscles. The longitudinal fibres of the mesenteron extend inbetween the caeca on the proventriculus and lie outside the circular fibres of this region.

(5) In the ventriculus the wall is unfolded. In the caeca, on the other hand, the wall is thrown into 6-10 folds of variable prominence.

(6) The mesenteric epithelium is composed of large digestive cells of the columnar type at the base of which are distributed the regenerative nidi. The columnar cells possess a well developed striated border.

(7) The muscularis of the mesenteron is poorly developed, comprising a fine circular layer with separate longitudinal fibres extending outside it.

(8) Both valves seem to be non-efficient. No additional circular fibres are observed in their regions.

(9) The proctodaeal wall is thrown into 12 longitudinal folds, low in the ileum but so prominent in the colon. In the rectal sac these folds are modified into 6 pad-like papillae with remote intima.

(10) The proctodaeal intima is thinner than in the stomodaeum. It is almost smooth or pitted, but devoid of any spines or setae.

(11) The epithelial lining is mainly columnar. In the colon the cells are flattened with indistinct boundaries. Pigment granules are present in the anterior part of the ileum and in the irregular cells between the rectal papillae.

(12) The circular muscle layer is generally thin except in the colon and rectum proper. The external longitudinal fibres aggregate in 6 bands that alternate in position with the internal folds. The longitudinal fibres of the ventriculus aggregate in 12 bands that extend inbetween the bases of the Malpighian tube groups on the pyloric region.

(13) The connective tissue is generally well developed especially below the folds.

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POLLINATORS OF THE CHIEF SOURCES OF NECTAR AND POLLEN GRAIN PLANTS, IN EGYPT

(with 2 Text-Figures)

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INTRODUCTION

Pollinating insects can be classified into two groups : (1) the so-called wild pollinators over which man has little control, and (2) the controlled group represented by the honeybee. Their limitations and potential pollinating values can be grouped into four categories, as follow:

(1) INSECTS WHICH DO NOT PROVIDE FOOD FOR THEIR BROOD: The pollinating activity of this group is a direct response to hunger and ceases as soon as their individual food requirements is met. This category represents the lowest forms of pollinators and is examplified by beetles, butterflies, moths and flies which commence pollination accidently because, as a rule, the construction of their bodies is not suitable for lodging of pollen grains.

(2) INSECTS WHICH PROVIDE FOOD FOR THEIR BROOD: This category includes solitary bees, such as *Megachile*, *Anthidium* and *Andrena*, etc... Many of these possess special adaptation for carrying loads of pollen because of their bodies covered with hair. Their increased pollinating activity is not only a result of collecting food for themselves, but also an instinct to provide food for their brood. The only factor which limits their activities as pollinators is that the female lays few eggs and that only a few generations occur annually, either but only one in many species.

(3) INSECTS WHICH STORE SURPLUS POLLEN AND NECTAR IN SPECIAL CELLS WITHIN THEIR NEST IN ADDITION TO GATHERING FOOD: As far as this work reveals no representatives of this category exist in Egypt.

(4) INSECTS WHICH LEAD A HIGHLY DEVELOPED SOCIAL LIFE: They are represented by species belonging to the genus *Apis* and by hive bees such as *Apis mellifera* with its numerous varieties.

REVIEW OF LITERATURE

SHAW, BOURNE and LOTHROP (1936) in U.S.A., studied the insect pollinators of onion. They gave the duration of activity, condition of temperature, relative humidity and wind velocity at which they were found. They stated that honeybees represented 31.8% of the insects caught; *Halictus*, then *Eristalis*, being next in abundance and importance.

SHAW, BAILEY and BOURNE (1939) indicated that the honeybee was the single numerous species visiting blueberries, bumble bees were next in abundance and solitary bees ranked third.

VANSELL (1942) pointed out that honeybees were the most common blossom visitors forming 62% of the captured insects while blowflies represented 23% and other species were scarce.

GUBIN (1945), in U.S.S.R., reported that flax was visited by honeybees at the rate of 93.3% of the entire pollinators.

Thrips, beetles, butterflies, moths, flies, solitary bees, bumblebees and honeybees were reported to be pollinators of cultivated crops (ROOT 1950, and SHAW 1951), in U.S.A. SHAW added that the hymenopterous insects were of special significance, and bees including solitary bees, bumble bees and honeybees were the most important pollinating agent.

According to CHARLES and ELLYN (1955) pollination under natural conditions performed by insects was mostly done by bees.

LOVELL (1924), in U.S.A., mentioned that bumblebees and honeybees were trippers of alfalfa.

GRAY (1952), in England, indicated that syrphid flies, *Bombus* and megachiles were pollinators of clover.

BURRIL (1926), in U.S.A., investigated the gathering ability of nectar by honeybees from flowers with long corollas and came to the conclusion that nectar was collected through holes made by larger bees and other insects. In England bumble bees were seen by SYNGE (1947) biting holes at the base of the unopened flowers of *Vicia faba* to suck nectar. BUTLER (1954), in England, and BOHART and NYE (1956), in U.S.A., stated that certain species of bumble bees were actually harmful, since, by biting holes at the bases of the corolla tubes they obtain the nectar without making contact with the stamens and stigma, and enable honeybees to do likewise.

PHILLIPS (1933), ANDERSON (1944), CHARLES and ELLYN (1955), in U.S.A, BRAUN (1949-1953), in Canada, found that bumble bees and honeybees were the principal pollinators visiting the red clover. In addition to these two species ANDERSON (1944) and BRAUN (1949-1953) stated that butterflies, *Andrena*, *Megachile*, *Halictus*, *Lassiosglossum*, *Heriades* and *Ceratina* were pollinating agents working on red clover.

VANSELL (1942), LINSELY (1946), VANSELL and TODD (1947), DRAKE (1948), in U.S.A., proved that honeybees were the most important pollinators of alfalfa.

VANSELL, LINSELY and DRAKE also showed that other insects were thrips, butterflies, *Andrena* sp., halictids, megachilids, *Melisodes*, *Bombus* sp., *Osmia*, and *Anthophora*.

HOLLOWELL (1944), in U.S.A., indicated that honeybees and various species of wild bees were efficient cross pollinators of legumes.

FRANKLIN (1952), in U.S.A., illustrated that leaf-cutting bees, bumble bees, hairy flower bees, carpenter bees, were important visitors of legume flowers in Kansas.

HOOPER (1931), in England, showed that fruit tree pollinators were *Osmia*, *Andrena*, *Halictus*, bumble bees and honeybees. HOOPER also found that ants, flies butterflies, moths, beetles, thrips and earwings visited fruit blossoms.

Nothing was found in literature concerning pollinators on citrus.

VANSELL (1942), in U.S.A., illustrated that the sugar concentration in the extra-floral (bract) nectar was about double that of the blossom nectar.

GROUT (1955), in U.S.A., found that cotton pollinators were honeybees and wildbees. He pointed out that floral nectaries has a sugar concentration of 20-30%, but exposed extra-floral nectar may reach a concentration of 60-80%. He added that, naturally, the honeybee would go to the most concentrated source, the extra-floral nectar, and would not visit the flower until this nectar was gone.

OBJECT OF THIS STUDY

The object of this work is to gain information about the pollinators of the main crops at Giza region.

The work is divided into two parts: (1) General survey of the insects pollinators visiting the selected crops and fruit trees; (2) A study of the seasonal activity of these pollinators all the year round on the chosen plants.

METHODS AND TECHNIQUE

Collecting pollinators visiting broad beans (*Vicia faba*), clover (*Trifolium alexandrinum*), cotton (*Gossypium* sp.) and citrus trees in Giza region, was practised regularly in these crops during 1954-1956 at the Farm of Faculty of Agriculture.

As soon as the crop started to bloom, daily records of the pollinators were made. An area of 5 × 5 metres was selected in each of the first three crops for studing the distribution of the insect pollinators of that crop. General collection of insects visiting the flowers of that crop was made.

Daily collecting was done during 1954 and 1955 for clover and cotton, and during 1955 and 1956 for broad beans and citrus trees. The climax of the blooming season of each crop was the richest period for both species and numbers of pollinators. The daily trip started usually at 9 a.m. and lasted to 4 p.m.

GENERAL SURVEY

As a result of the continuous catch of the pollinators visiting the selected crops, either by net or the aspirator, about 120 species were collected during the two years period of investigation. Six of the species belonged to the order Lepidoptera, sixteen to the Coleoptera, fifteen to the Diptera and eighty-three to the Hymenoptera.

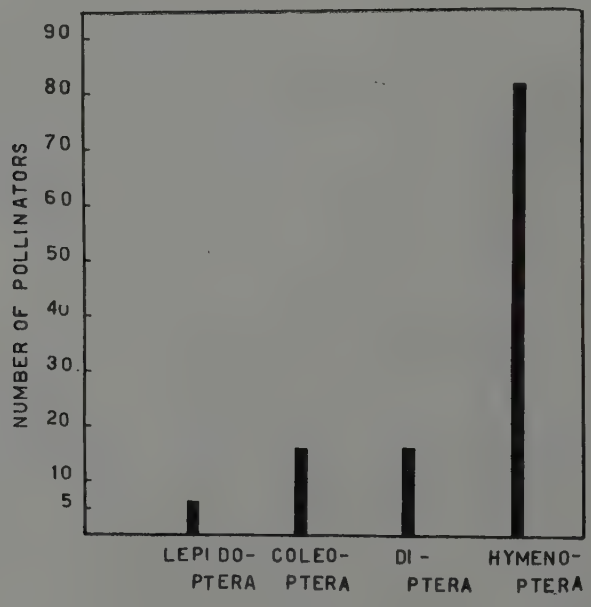

FIG. 1: Number of the different species of pollinators according to their orders.

Some of the pollinators limit their visits to a definite crop, e.g. *Anthophora senescens* Lep. which is confined to broad beans, *Colias croceus* Fourc. to clover and *Earias insulana* Boisd. to cotton. Other species are found on more than one crop, e.g. *Syrphus corollae* F. visiting citrus trees and clover, and *Tropinota squalida*

Scop. broad beans, citrus and clover. Some of these pollinators however, e.g. *Cataglyphis bicolor* Fabr., *Xylocopa aestuans* L. and *Apis mellifera* L. visit all four plants mentioned above.

The duration of their activity varies considerably. The majority are particularly active during May-July inclusive, while few are only seen during winter (*Anthophora senescens* Lep., *A. lanata* Klug, *A. speciosa* Fr., and *Chalichodoma siculum* Rossi). A limited number extend their activity to over six months, e.g. *Cataglyphis bicolor* Fabr. and *Xylocopa aestuans* L., which were observed working on the four food sources.

The activity of the honeybee *Apis mellifera* L. continued throughout the year.

BROAD BEANS POLLINATORS

The blooming season of the broad beans starts in the middle of December and ends in the first half of February. The nectar glands are found at the bottom of the long corolla tube of the flower, therefore only insects having long proboscis can reack and such the nectar.

About thirteen pollinators were found on broad beans (Fig. 2), as follow:

(1) *Pieris rapae* L. (the cabbage butterfly) visits the flowers of broad beans. It stands on the flower and the keel by the aid of its fore-legs. This position causes the stamenal column with the anthers surrounding the pistil to appear. Then, the butterfly extends its proboscis until it reaches the nectar and starts to suck it. While it feeds it comes into contact with the anthers. The proboscis and the anterior part of the head are seen covered with pollen grains. *Pieris rapae* L. is a diurnal insect and usually it visits the flowers during the morning. While it is on wing it visits a small number of flowers and usually shifts from one crop to another, thus it cannot be considered a reliable pollinator. Its active season usually starts from the middle of January until the end of the blooming season.

(2) *Tropinota squalida* Scop. (the furry rose beetle):

The adult insect feeds on pollen grains. It injures the flowers by slitting and biting the petals of the corolla until the staminal column appears. In many cases it bites the ovary and thus prevents the developing of pods.

The body of the bettle is covered with yellowish gray hair capable of retaining great quantities of pollen grains. The insect visits roses at the beginning of February, citrus trees in March and April, and clover during May and June, and disappears until the following winter. The beetle visits the flower of broad beans in the early hours of the morning and late in the afternoon. It is active from the beginning of December until the end of February.

(3) *Cataglyphis bicolor* Fabr.: This ant visits the flowers to feed on nectar either by biting the corolla and descending down its tube or by entering through a

hole previously made by *Xylocopa aestuans* L., thus reaching the nectar glands. After feeding it moves upwards the corolla and on its way it comes in contact with the anthers and thus some of the pollen adheres on its body and is carried to another flower. As the body of the ant is not covered with hair, the quantity of pollen grains carried is very small and thus it is not considered a good pollinator. It is observed during all the blooming season.

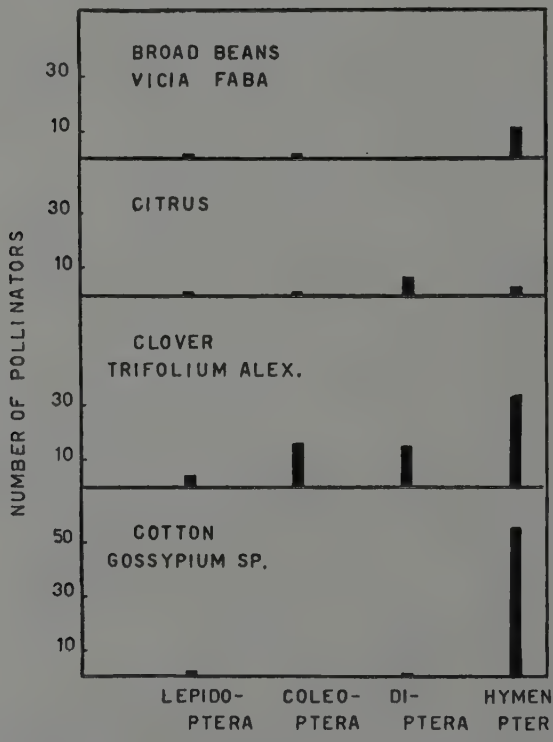

FIG. 2: Number of the different species of pollinators working on selected crops according to their orders.

(4) *Anthophora senescens* Lep., (5) *Anthophora lanata* Klug., (6) *Anthophora speciosa* Fr. (furred bees), are very important pollinators of broad beans. These insects possess long proboscis and their bodies are covered entirely with hair which enables them to carry a large quantity of pollen grains. The insect stands on the flower, and due to its weight, the keel opens and the staminal tube appears allowing the insect to extend its proboscis until it reaches the nectary. In the meanwhile its

head and prothorax, become in contact with the anthers which are thus covered with pollen grains. Anthophorids visit many flowers within a short time. They work on broad bean flowers in the early morning and in the late afternoon. The climax of their activity is during January.

(7) *Chalichodoma siculum* Rossi (mason bees) visits only the broad bean flowers in the same manner as the anthophorids. It has a long proboscis with which it gathers nectar, and has a hairy coat which enables it to carry pollen grains and to be an effective pollinator. It is active all day long during January.

(8) *Tetralonia lanuginosa* Klug and (9) *Tetralonia cuniculina* Klug obtain nectar and pollen grains from broad bean flowers. When visiting a flower their proboscis is inserted in it and their body comes in contact with the pollen grains scattered from the anthers. The body being covered with thick hair enables the insect to carry a large quantity of pollen grains. The insect flies amongst widely spaced plants. *Tetralonia* is active during the month of January.

(10) *Nomada mauritanica* Lep. visits the flowers of broad beans to obtain nectar. In passing through the corolla it comes in contact with the anthers and its body becomes partly covered with pollen grains. As the insect's body bears a small quantity of hair it is an ineffective pollinator. This insect is active during January.

(11) *Melecta* sp. visits the broad bean flowers to gather nectar and pollen grains. During its visit it enters the flower, extends its proboscis until it reaches the nectary and begins to suck the nectar. Meanwhile the body and legs, especially the femur of the middle pair which are covered with hair, becomes loaded with pollen grains. *Melecta* works in the morning and late in the afternoon and visits but only many broad bean flowers. January is the time during which this insect is active.

(12) *Xylocopa aestuans* L. (carpenter bee): Each sex of this insect visits the flowers of broad bean in a different way. The male usually pierces the calyx and corolla at their base by the maxillae, and sucks the nectar. The insect moves quickly and sometimes causes damage to the flowers. The female gathers pollen grains. It enters the flower from the top and by the aid of its forelegs moves the flower wings apart and opens the keel exposing the anthers. As the insect is covered with thick hair, it is capable of carrying a large quantity of pollen grains.

It has been seen that the part played by the male insect is not as important as that played by the female which is regarded as an effective pollinator. *Xylocopa* was found visiting the flowers during all the blooming season.

(13) *Apis mellifera* L. (the honeybee): The honeybees working on broad bean flowers are divided into two groups, the nectar and the pollen gatherer. Honeybees usually collect nectar from flowers through the holes which has been previously made by the carpenter bees or ants, because of their proboscis and maxillae being not strong enough to pierce flowers. Therefore, the nectar gathering bees play no part in the pollination of broad bean flowers. This group of bees start foraging from 11 a.m.

The group of bees concerned with pollen gathering are seen standing on the flowers, and by the aid of their forelegs they move the flower wings, open the keel and go round the anthers until their bodies are loaded with pollen grains. Before returning to their hives they pack the pollen grains in the pollen basket of their hind-legs in the form of pollen pellets. The pollen gathering bee visits many flowers in each trip within a limited area.

During the blooming season of broad bean, and unless the weather conditions are not suitable for flying, the honeybees start their daily activity working on ornamental plants such as *Reseda odorata* from about 8-10 a.m., then shifts to broad bean flowers. Pollen gathering activity is usually at its peak from 1 to 2 p.m.

CITRUS POLLINATORS

In Egypt the citrus tree blooming season lasts from the beginning of March until the last week of April. Ten different species of pollinators have been seen working on the blossoms (Fig. 2), as follow:

(1) *Pieris rapae* L. (the cabbage butterfly) visits the flowers in small numbers, usually during midday, to feed on the nectar found around the base of the ovary. It does not feed on pollen grains, but while searching for nectar it comes in contact with the stigmas which get pollen scattered on the body scales. When the insect goes to another flower pollination takes place.

This butterfly has not a fixed area within which it works but usually moves between trees which are at a far distant apart. It is active throughout the citrus blooming season.

(2) *Tropinota squalida* Scop. (the furry rose beetle) visits citrus flowers to consume only their pollen grains, and in the meantime the rest of the flower parts remain unmolested.

The role played by this insect as a pollinator to citrus blossoms depends on the way it enters the flower. It inserts its head in the space between the stamens and pistil to obtain pollen without damaging this part. After doing so its body gets covered with a large quantity of pollen grains which it carries to other flowers. The insect usually moves from one flower to another on the same branch resulting in the aid of self-pollination. Its activity is observed during all the citrus blooming season.

(3) *Syrphus corollae* F., (4) *Syrphus balteatus* Deg., (5) *Xanthogramma aegyptium* Wied. (hoverflies) visit the citrus flowers to feed on nectar. In making their way to the nectaries their bodies get partly covered with pollen grains. These flies hover around the flowers of the same plant and do not leave until a noticeable time passes. They always prefer the sunny parts of citrus trees and were found visiting the flowers during all the blooming season. *Xanthogramma* was active only during April.

(6) *Eristalis quinquelineatus* Fabr. and (7) *Eristalis tenax* L. (droneflies) were observed in small numbers working on the blossoms of citrus trees usually in the morning. They start hovering around the flower before entering it and then move to another flower of the same kind or shift to other plants and weed flowers. Unlike the previous flies they prefer the shady parts of the trees. *Eristalis quinquelineatus* was active during all the blomming season. *Eristalis tenax* was found visiting the flowers only during April.

(8) *Cataglyphis bicolor* Fab.: This ant usually visits citrus trees which have been previously infested with *Aphis*, to feed on their honeydew secretion. The aphids are found on the petals of the corolla in infested flowers throughout the blooming season and attract *Cataglyphis*. Although the ant comes in contact with the anthers, its glossy body is incapable of carrying great quantities of pollen grains. Therefore, *Cataglyphis* is not regarded as an effective pollinator. Pollination takes place but only incidently.

(9) *Xylocopa aestuans* L. (the carpenter bee): visits citrus flowers to feed on nectar during all the blooming season. They stand on the petals, moves their proboscis and begins to feed. In doing so the lower surfaces of the thorax and abdomen becomes covered with pollen grains.

(10) *Aphis mellifera* L. (the honeybee) is the most common pollinator of citrus flowers. It visits the flowers either for nectar or pollen grains. The nectar gatherers pay a longer visit to the flower. While gathering nectar the bee stands on the petals of the corolla and inserts its proboscis in such a way that it does not come in contact with the stamens.

The pollen gathering honeybee rapidly moves over the anthers, until its body and legs are covered with the pollen grains. Then it bites the anthers with its mandibles and pulls them towards and somewhat beneath its body with its forelegs. In returning back to the hive, it gathers the pollen grains from its thorax and abdomen and packs them in the pollen basket in the form of pollen pellets on its hind legs.

Pollen and nectar gatherers limit their activities to certain parts of the tree. By using stop watch, the honeybee stays from 15 to 20 seconds in nectar gathering; while in pollen gathering it spends only 5 to 8 seconds.

The honeybee visits either the opened or the unopened flowers. The unopened flower buds are opened by the aid of the forelegs without being damaged.

When gathering nectar the honeybee prefers the unopened flowers or the newly opened ones, but in pollen gathering it prefers the full opened flowers. Nectar gathering begins much earlier in the day than pollen gathering.

CLOVER POLLINATORS

The flower of the Egyptian clover (*Trifolium alexandrinum*) is of the leguminous type. Two of the petals are interior and united to form the keel within which

the stamens are found. When the keel is forced open these parts spring and pollen is liberated. The tripping mechanism must be released by an external agent such as a bee or other insect searching for pollen or nectar. Nectar glands are found at the base of the corolla tube around the ovary.

Clover blooming season begins from about the first week of May till the end of June.

Sixty-nine different species of pollinators were found working on the flowers of clover (Fig. 2), as follow:

These pollinators are ranked according to their orders and families.

(1) *Pieris rapae* L. (the cabbage butterfly) visits clover flowers to suck nectar during the early morning and late afternoon during all the blooming season. To reach its food it opens the flower parts by its fore-legs, and inserts its proboscis in the "throat" of the flower. A very small quantity of pollen was seen on the proboscis, and no other part of the insect body was observed carrying pollen grains. Thus, the function of this butterfly in pollination is very small.

(2) *Colias croceus* Fourc. (the clouded yellow butterfly) is seen in large numbers in clover fields. It visits the flowers usually during midday. On feeding on nectar some pollen grains sticks to the proboscis. It is activity during all the blooming season, having a peak in the last days of May, but is of slight importance in pollination.

(3) *Cosmolyce baeticus* L.: This small butterfly is found in large numbers on clover heads. Because of its short proboscis it is obliged to open the flower keel and enter in it to some distance to reach the nectar glands at the base of the staminal tube. In doing so it comes in contact with the flower anthers and a large quantity of pollen grains adheres on its body. It was found during all the blooming season, but has a peak during the first days of May. This butterfly is more effective in pollination than any other one visiting clover flowers.

(4) *Vanessa cardui* L. (the painted lady butterfly) has almost the habits of the cabbage butterfly. It is seen rarely visiting clover flowers during the blooming season.

(5) *Paederus alfierii* Koch., a Staphilinid beetle entering the flowers during May and June. It was not observed feeding on nectar or pollen. In passing through the flower it comes in contact with the anthers and a small quantity of pollen grains fixes on its body.

(6) *Ptosima undecim-maculata* Hbst., a Buprestid beetle rarely found on clover during May and especially in the morning. It cuts the petals of the corolla till it reaches the anthers and feed on pollen grains. The way of transferring pollen grains from one flower to another occurs through pollen borne on the mouth-parts.

(7) *Anthaxia stupida* Mars., another Buprestid beetle feeding on pollen grains. With the aid of the first pair of legs it opens the flower, enters it, and thus the body becomes dusted with pollen which it transfers to another flower. This insect was found during the last days of the clover blooming season.

(8) *Attagenus scalaris* Pic, (9) *Attagenus annulifer* Cast., (10) *Anthrenus* sp., (11) *Dermestes frischi* Kugel, and (12) *Trogoderma* sp. These five Dermestid beetles are very effective in the pollination. They are active all day long. They visit the flowers to feed on pollen grains. They enter the flower keel and bite the anthers. Pollen grains are carried to other flowers on the body hairs. *Attagenus* spp., *Anthrenus* sp., and *Trogoderma* sp. were found on the flowers from the middle of May till the end of June, and *Dermestes frischi* from the first of May and till the end of June.

(13) *Coccinella undecimpunctata* L., (14) *Rodalia cardinalis* Muls., and (15) *Hyperaspis marmottani* Fairm. are three predaceous Coccinellid beetles visiting the flowers to search for aphids to feed upon. Pollination takes place incidently. *Coccinella* was found more abundant on clover heads than *Rodalia* and *Hyperaspis*. These beetles were observed more often during the early morning and specially at the field edges, where aphids are more abundant. *Coccinella* visits clover during May and June, while *Rodalia* and *Hyperaspis* were found from the first of May up to the middle of June.

(16) *Spermophagus sericeus* Geoffr., a Bruchid beetle visiting clover rarely. It penetrates into the flowers to feed on pollen grains. The insect body bears some hair capable of holding a small quantity of pollen grains. It showed its activity from the middle of May to the last days of June.

(17) *Tropinota squalida* Scop. (the furry rose beetle) causes a great damage to the flowers. By its biting mouth parts it cuts the petals and sometimes a great part of the flower pistil. The insect's main object is to feed on pollen grains, but it bites all the flower parts which come across it. Its activity was observed usually in the early morning during all the blooming season.

(18) *Cholorophorus varius damascenus* Chevr. (a Cerambycid beetle), (19) *Lixus ascanii* L. (a Curculionid beetle), and (20) *Trichodes longissimus* Ab. (a Clerid beetle), also visit the flowers to feed on pollen grains. The first two do not injure the flowers. *Trichodes*, however, damages many flowers. These insects enter the flower keel, pass over the anthers and bite it. They are less effective in pollination than the furry rose beetle. They were seen carrying small quantities of pollen grains on their bodies. *Chlorophorus* and *Lixus* appeared from the middle of May till the last days of June, but *Trichodes* was observed during May and June.

(21) *Syrphus corollae* F., (22) *Syrphus balteatus* Deg., (23) *Xanthogramma aegyptium* Wied., (24) *Eumerus vestitus* Bez., (25) *Syritta subtilis* Beck., and (26) *Sphaerophoria scripta* L.: These six hover flies visit clover flowers to feed on nectar. The first three hover, after feeding, around the clover heads. In searching for nectar they pass through the flower throat till they reach the nectaries. On this way, they are met with the anthers and their bodies become somewhat covered with pollen grains. These flies show their activity during all the day long. *Syrphus* and *Xanthogramma* were found visiting the flowers during all the blooming season. *Eumerus*

and *Syritta* appeared from the first of May till the middle of June and *Sphaerophoria* was observed during May only.

(27) *Eristalis quinquelineatus* Fabr. and (28) *Eristalis tenax* L. (drone flies) rarely visit clover flowers. They feed only on nectar. In opening the flowers to reach the nectaries they come across the anthers and their heads become covered with pollen. They show their activity during all the blooming season.

(29) *Gonia bimaculata* Wied., (30) *Calliphora erythrocephala* Meig., and (31) *Sarcophaga* spec. are three flies rarely visiting clover. The hair found on their bodies make them capable of bearing pollen grains. They were found visiting the flowers of clover during the middle period of its blooming season from the middle of May up to the middle of June.

(32) *Lucilia sericata* Meig., (33) *Musca* sp., and (34) a *Bombylid* are three flies having the same habits as the previous ones. Their number is usually small. *Lucilia* and the Bombylid were found visiting the flowers from the first of May till the middle of June, while *Musca* appeared from the first of May till the late June.

(35) *Henicospilus* sp., (36) *Nototrachys foliator* F., and (37) *Pimpla roborator* F. are three hymenopterous insects which visit clover flowers to feed only on nectar. They have no special apparatus for collecting pollen. In passing through the flower to obtain their food, they come in contact with the anthers and small quantities of pollen stick on their bodies. Their activities occur usually during the morning, visiting the flowers from the first of May to the end of June.

(38) *Dichrysis bihamata* Spin., (39) *Hedychridium* sp., (40) *Trichrysis scioensis* Grip., (41) *Hexachrysis lyncea* F., (42) *Stilbum cyanurum splendidum* F., (43) *Tachysphex* sp. These six hymenopterous insects feed on nectar during all the clover blooming season. On their way to the nectar glands, they are met with the anthers and their bodies become somewhat covered with small quantities of pollen grains.

(44) *Philantus abdelkader* Luc. (the bee wolf) is a predator visiting the flowers from the middle of May till the end of the blooming season. It catches some of the honeybees which are visiting clover heads and transfers them to its nest for feeding. It is found also feeding on nectar of the flowers. The way of transferring pollen grains from one flower to another is by pollen borne on its head.

(45) *Vespa orientalis* F. (the hornet) and (46) *Polistes gallica* Lep. are found in clover fields visiting the flowers to suck nectar during all the blooming season. On their way to the nectar glands, they are met with the anthers and their heads become covered with small quantities of pollen grains. Also they are predators feeding on worker honeybees. They stay long in one part of the field, and do not move to another part until after a long time.

(47) *Cataglyphis bicolor* Fab. is an ant occuring in great numbers in clover fields during all its blooming season, it bites any part of the flower, feeds on nectar

and pollen but its harm is not so great, its glossy body do not help it to bear great quantities of pollen grains.

(48) *Megachile flavipes* Spin. and (49) *Megachile nigripes* Spin. (the leaf-cutting bees) are two very important pollinators of clover during all its blooming season. They visit the flowers to feed on nectar and pollen which they carry to their nests. The insect places its head against the standard petal, puts its legs upon the keel petals and pushes itself in the flower. This action forces the keel petals to open and to release the staminal tube, thus the ventral part of the insect body becomes dusted with pollen grains. The prothoracic and mesothoracic legs are used to pack the pollen on the ventral side of the abdomen when the insect moves from one flower to another. They are structurally adapted to perform the collection of nectar and pollen. They visit a great number of flowers in a short time, more than do the honeybees. These insects were not seen cutting clover leaves or any other part of this plant. The thick hairy coat of the body specially on the ventral part of the abdomen, makes it a very good pollinating agent to clover flowers.

(50) *Anthidium* sp. (cotton bees) is rarely found in clover fields during all its blooming season. It has no special apparatus to collect pollen grains from the flowers. It feeds on nectar by lapping it with its mouth-parts. It has a small quantity of hair on its body capable of retaining pollen grains.

(51) *Andrena flavipes* Panz., (52) *Andrena rutila* Spin., (53) *Andrena munda* Walker, (54) *Andrena pseudovatula* Alfken, (55) *Andrena savignyi* Spin., and (56) *Andrena ovatula* N.K. visit clover flowers to feed on nectar and pollen. They are more effective in pollination than *Anthidium*. They are structurally adapted to gather pollen grains on their hind legs. They visit the flowers of clover usually in the morning, from the first of May till the middle of June.

(57) *Ceratina tarsata* Mor. and (58) *Ceratina dellatorreana* Friese, gather nectar from clover flowers during all the blooming season. Their body being glossy allows but a small quantity of pollen grains to fix on it during their visits to the flowers, thus these insects have a slight effect in pollination. They are found in clover fields during the morning and completely disappear in the afternoon.

(59) *Halictus callizonus* Per. and (60) *Halictus holtzi* Schulz., and (61) *Halictus copticus* Bl. (sweet bees) feed on nectar and pollen during all the blooming season of clover. *Halictus callizonus* and *Halictus copticus* are smaller and less hairy than *Halictus holtzi*, and therefore carry less pollen grains.

(62) *Crosisa ashabadensis* Rad. visits clover flowers in the late afternoon throughout all the blooming season. It rarely feed on both nectar and pollen. It was observed carrying pollen grains on its body specially on the femur of the middle and hind pair of legs.

(63) *Osmia violascens* Pev. and (64) *Osmia latreillei* Spin. are found abundantly in clover fields usually in the early morning and midday from the middle of May till the end of June. They are glossy and bear some hair on the thorax and

abdomen specially the ventral part, allowing them to carry moderate quantities of pollen on their bodies.

(65) *Nomada mauritanica* Lep. visits clover fields to feed only on nectar. It enters the flower through its throat, and comes across the anthers. Small quantities of pollen grains sticks on its body, thus it is not a good pollinator. This insect was found during all the blooming season.

(66) *Prosopis* sp. and (67) *Sphecodes olivieri* L. suck the nectar of the flower. They were seen carrying small quantities of pollen grains on their bodies during their visits to the flowers usually during midday and in late afternoon from middle of May till the end of June.

(68) *Xylocopa aestuans* L. (the carpenter bee) is an effective pollinator of clover. Its great weight helps in opening the flower keel mechanically. *Xylocopa* is found abundantly in clover fields all day long during the clover blooming season. Both sexes visit the flowers for nectar. During their visit the lower part of the head, thorax and the anterior part of the abdomen come in contact with the stamens, thus a great quantity of pollen grains fixes on the body hairs.

(69) *Apis mellifera* L. (the honeybee) is the most common insect visiting clover blossoms. It is structurally adapted to bear and collect pollen grains. The nectar gathering honeybee walks on the clover heads and thrusts its tongue into the flowers, and as a result the keel petals open and the staminal tube is released, striking the lower part of the head of the honeybee. The pollen is then transferred to the hind legs while the bee is resting on the clover heads. The pollen is collected as a supplementary load by the nectar gathering honeybee. No special effort is made in the collection of pollen except packing it in the pollen baskets.

The pollen gathering honeybee, alights on the flower wings, and forces the keel to open by pushing herself into the flower. The pollen is borne on the mouth parts, antennae, other parts of the head, fore and middle pair of legs. Then pollen is packed in the normal way while the bee is flying from one flower head to another.

Honeybees do not wander at random on the clover flowers, but confines themselves to a small area of the crop, which is called "the fixation area". Usually, nectar gathering takes place early in the morning till about midday, while pollen gathering takes place from about 11 a.m. till the late afternoon.

COTTON POLLINATORS

Cotton is one of the most important crops in Egypt. It is regarded as one of the main sources of nectar and pollen grains. It blooms from the last week of June till about the end of August.

Fifty-eight different species of pollinators have been seen visiting the cotton flowers (Fig. 2), as follow:

(1) *Pelopidas borbonica* Led. (the skipper butterfly) visits the flowers, from the beginning of July up to the end of August, to feed on nectar from the floral

glands inside the flower. During that visit, it comes in contact with the anthers and its body is somewhat covered with pollen grains which are transferred to other flowers.

(2) *Earias insulana* Boisd. (the spiny cotton bollworm) is abundant late in the cotton blooming season. It was seen visiting the flowers especially in the afternoon from the middle of August up to the end of the blooming season. During its visit some pollen grains stick on the insect body scales and pollination takes place when the moth goes to another flower.

(3) *Anthrax* sp. is the only dipterous insect which was seen visiting the cotton flowers. It enters the flower through its basal parts to lap nectar. During feeding pollen grains are collected on the hair found on the abdomen. Its activity is during the months of July and August.

(4) *Hexachrysis lyncea* F. and (5) *Stilbum cyanurum splendidum* F. are seen rarely visiting cotton flowers. They suck the nectar of the floral glands mainly in the morning. Their abdomens are glossy and bear a very small quantity of hair capable of holding pollen grains. *Hexachrysis* activity starts from the middle of July till the end of August.

(6) *Sphex pruinosus* Germ., (7) *Tachysphex* sp., (8) *Sceliphron targionii* Car., (9) *Oxybelus* sp., and (10) *Ammophila tydei* Guill. are seen usually visiting the flowers to feed on nectar during the afternoon. They have some hairs on their bodies capable of retaining pollen grains, thus they serve as pollinators. *Sphex* is active from the middle of July till the middle of August. *Tachysphex* shows its activity from the beginning of the blooming season till the end of August. *Sceliphron* is active from the middle of July till the end of August. *Oxybelus* is seen only during August. *Ammophila* is found from the middle of July till the middle of August.

(11) *Philanthus abdlekader* Luc., (12) *Philanthus niloticus* Smith, and (13) *Philanthus triangulum* F. visit cotton flowers to catch honeybees and feed on them, thus they are predaceous insects. They also visit the flowers to have nectar. Their head and thorax are covered with pollen. *Philanthus abdelkader* was seen visiting cotton during all the blooming season, but *Philanthus niloticus* and *triangulum* were only seen from the middle of July till the end of August.

(14) *Crabro arabs* Kohl visits cotton flowers all day long. It feeds on nectar of the floral glands. It was seen bearing small quantities of pollen grains on its body during its visits to the flowers. It is also predaceous, feeding on other wasps and bees. Its activity was observed during August.

(15) *Larra anathema* Rossi is a predaceous wasp which also feeds on nectar. During feeding its body becomes covered with pollen. It was found visiting the flowers from the middle of July till the middle of August.

(16) *Liris haemorrhoidalis* F. has the habit of visiting the flowers for a short-time. The body and legs are covered with hair capable of holding quantities of pollen grains. It is active during the morning and disappears completely during midday. It is seen from the first days of August till the end of the blooming season.

(17) *Astata* sp. visits cotton flowers to feed on nectar. It carries small quantities of pollen grains on its body. Its activity was observed only during August.

(18) *Odynerus enslini* Sch., (19) *Odynerus oculatus* F., (20) *Odynerus alexandrinus* S.S., and (21) *Odynerus crenatus* Sch. are all predaceous wasps belonging to the family Eumenidae. They sting larvae, and carry them to their nest. They are seen rarely feeding on nectar of the flowers although small particles of pollen were seen fixed on the insect's bodies during their visits to the flowers. Their activity starts from the first days of July till the middle of August.

(22) *Eumenes pomiforms* Rossi., (23) *Eumenes companiformis* S.S., and (24) *Eumenes maxillosus* F., visit cotton flowers from the beginning of August till the end of the blooming season, during midday, to feed on nectar. During feeding, they come in contact with the anthers, and a small quantity of pollen fixes on their bodies.

(25) *Bembex chlorotica* Spin. and (26) *Bembex lusca* Spin. are very rarely found in cotton fields. They fly quickly from one plant to another. They were seen bearing pollen grains on their bodies during their visits to the flowers to feed on nectar. Their activity starts from the beginning of July till the end of August.

(27) *Vespa orientalis* F. is a predaceous wasp commonly seen during all the cotton blooming season. It collects some pollen on its body.

(28) *Ancystrocerus biphaleratus* S. is seen rarely visiting cotton flowers from the middle of August up to the end of the blooming season. It feeds on nectar. Some pollen grains are carried by the insect's body during its visit to the flowers.

(29) *Polistes gallica* Lap. is a very common wasp found all the year round on plants which are visited by honeybees. It visits cotton flowers to wait for honeybees, sting them, and carry them as food for its brood. In this way they become pollinators as they come in contact with the anthers during their visits. It was observed visiting cotton flowers during all the blooming season.

(30) *Cerceris capito* Lep., (31) *Cerceris fischeri* Spin., and (32) *Cerceris erythrocephala* Dahl. are seen during the middle of August catching *Halictus copticus* to carry it in its nest. They also feed on the floral nectar, and in doing so their body becomes covered with small quantities of pollen grains. Their activity start at the middle of August and terminate with the end of the blooming season.

(33) *Cataglyphis bicolor* Fab., an ant which always visits cotton flowers of the same plant or the plant near by during all the blooming season. It feeds on nectar from the floral and extra-floral nectaries, and sometimes bites the flower parts and causes damage to it. Its body is smooth and can carry but a small quantity of pollen.

(34) *Scolia erythrocephala* F. and (35) *Scolia collaris* F. are hairy wasps visiting cotton flowers to feed on nectar of the floral nectaries. In entering the flowers their bodies touch the anthers and become covered with pollen grains. They are most effective pollinators, especially *Scolia collaris*. These insects are more nectar collectors than they are predators. They rarely visit the extrafloral nectaries.

They show their activities all day, specially at noon, and observed during the month of August.

(36) *Mezine arabica* Guér. and (37) *Mezine zonata* Guér. are found rarely visiting cotton flowers. They enter the flowers and feed on the floral nectar. At the height of the blooming season they are seen always during the morning before 10 a.m. and later they disappear. Their activities were observed during August.

(38) *Stizus bizonatus* Spin., (39) *Stizus cheops* Mor., (40) *Stizus tenellus* Klug, (41) *Stizus succineus* Klug, (42) *Stizus niloticus* Handl., and (43) *Stizus ferrugineus* Smith. are found usually in cotton fields, specially *Stizus bizonatus*. They are predators and also feed on nectar. On their way to the nectar glands, they are met with the anthers and their bodies become somewhat covered with quantities of pollen grains. They visit cotton fields usually during mid-day. Their activity occurs during the month of August.

(44) *Cryptochilus niloticus* Handl. was seen only in August, during the last days of the blooming season. It enters the flower to search for nectar of the floral nectaries. In that way its abdomen became covered with pollen, but the quantity of pollen is somewhat small and therefore it cannot be considered as a good pollinator.

(45) *Ctenagenia vespiformis* Klug was very rarely seen visiting cotton flowers. It enters the flowers to search for bees, which are caught and carried home as its diet or for its brood. It feeds also on nectar from inside the flower and in this way a small quantity of pollen grains sticks on its body. Its activity begins from the middle of August till the end of the blooming season.

(46) *Telostegus melanurus* Klug is common in cotton fields during the month of August. It visits the flowers to feed on the extra-floral and floral nectaries. Pollination of flowers occurs from pollen grains adhering on the insect body. It visits the flowers in the morning, but at noon it stands lazily on the leaves. It is also predaceous for it was seen catching spiders resting on the flowers.

(47) *Cyphononyx flavicornis* F. is observed during August. It visits the cotton flowers in search of nectar. It remains in the flower for a long time and feeds on the floral nectar. Its body was seen usually covered with great quantities of pollen. It shows its activity in the morning between 8 and 10 a.m., and in the afternoon between 3 and 4 p.m.

(48) *Mutilla interrupta* Latr. a small wasp usually found in the flowers of cotton during all the blooming season. It feeds on nectar and its abdomen becomes covered with pollen grains in large quantities. It works usually in a certain part of the field.

(49) *Anthophora quadrifasciata* Vil. and (50) *Anthophora savignyi* Lep. visit cotton flowers from the second half of July till the end of August. These insects gather both pollen and nectar only from the floral nectaries. *Anthophora* are very important pollinators of cotton. Their bodies are covered entirely with hair which enables them to carry a large quantity of pollen grains.

(51) *Anthidium* sp. is a small bee visiting cotton flowers in the early morning to gather nectar from the floral nectar glands. Its body is not thickly covered with hair and it cannot bare much pollen, thus it is not considered a good pollinator. It works on the flowers very rapidly, and visits them from the beginning of the blooming season till the first two weeks of August.

(52) *Halictus copticus* Bl. is a small bee visiting cotton flowers in the early morning to collect both nectar and pollen. It was seen bearing small quantities of pollen grains on its body. It occurs in cotton fields from the beginning of the blooming season till the end of August.

(53) *Crocisa ashabadensis* Red. visits cotton flowers to collect nectar. Its abdomen is covered scantily with hairs enabling it to collect little pollen. Some pollen is also collected on the femur of the middle and hind legs. It shows its activity from the first days of the cotton blooming season till the middle of August.

(54) *Colletes* sp. is a small bee which collects both pollen and nectar from inside the cotton flowers. It was seen bearing pollen grains on the thorax and both the middle and hind legs. It works on the flowers very rapidly and visits usually the plants which are near the roads and bounderies of the field. Its activity is usually all over the day from the second half of July till the end of August.

(55) *Prosopis* sp. visits the flowers to obtain nectar from the floral nectar glands, and also to feed on pollen grains. Its body is not adapted to carry great quantities of pollen grains, thus it is not considered a good pollinator. It shows its activity during all the blooming season.

(56) *Sphecodes olivieri* L. visits cotton flowers to obtain nectar and in this way a small quantity of pollen grains adheres on the insect body, specially on the abdomen. It was observed during all the blooming season of cotton.

(57) *Xylocopa aestuans* L. the female of which is usually seen visiting the floral nectaries and forcing its proboscis between the calyx and corolla during the morning. The male enters the flower to feed on nectar, and in doing so its body became covered with pollen grains. In mid-day the female insect was observed collecting nectar and pollen grains from inside the flower. Both sexes visit cotton flowers during all the blooming season and are usually active during mid-day.

(58) *Apis mellifera* L. (the honeybee) visits cotton during all the day long. In the early morning nectar gathering honeybees usually prefer the extra-floral nectaries. During mid-day the nectar gatherer usually sucks nectar from the floral nectaries, but from outside, pushing its proboscis in the space between the calyx and corolla. Pollen collection begins from about 9-10 a.m. and lasts with the end of the day. The honeybee enters the flower, passes round the anthers and pushes the proboscis in the space between the base of the petals to suck nectar. Meanwhile, its body becomes covered with pollen grains which are packed into pollen pellets during the flight to another flower. Both nectar and pollen gathering honeybees have fixation areas for their activities on cotton. They visit the flowers during all the blooming season.

CONCLUSION

A survey was made on the pollinators of the main nectar and pollen plants in Egypt during the years 1954 to 1956.

About 120 species of pollinators visiting the studied crops, were collected. Six of these species belonged to Lepidoptera, sixteen to the Coleoptera, fifteen to the Diptera and eighty-three to the Hymenoptera. Thus, the latter order represented the largest number of pollinators. Of the hymenopterous insects wild bees were very effective in pollination as they are structurally adapted to carry pollen grains on their bodies.

Pollinator insects had different active seasons. Some were active during winter months such as *Tetralonia* and *Melecta*. The majority, however, were active between May and July.

Some pollinators limited their activities to one crop, e.g. *Anthophora senescens* which visited broad beans only. *Colias croceus* visited clover. Other species visited more than one crop such as *Tropinota squalida* which visited broad beans, citrus and clover, also *Cataglyphis*, *Xylocopa* and *Apis mellifera* which visited the four chosen crops.

Some injurious insects such as *Ptosima undecimmaculata* acted as pollinators when visiting the flowers.

The broad bean pollinators comprised thirteen species, eleven of which belong to order Hymenoptera, the other two to the Lepidoptera and Coleoptera. Anthophorids are very important pollinators of broad beans as they are capable of bearing large quantities of pollen grains. They visit many flowers in a short time, but they are few in number. The femur of the middle pair of legs of the *Melecta* sp., which are covered with thick hair, helps it in carrying pollen from the flowers of which it visits. The male of the carpenter bee (*Xylocopa aestuans*) injures the flowers, the calyx and corolla at their bases. The nectar gathering honeybee depends on these holes to reach the nectaries. Thus, both the nectar gathering honeybee and the male carpenter bee are ineffective pollinators of broad beans.

During the blooming season of broad beans, honeybees visit ornamental plants from 8-10 a.m., then shift to broad beans. The pollen gathering bees start earlier than the nectar gathering bees and reach their peak between 1-2 p.m.

The citrus pollinators are ten in species. One species belongs to the order Lepidoptera, another to the order Coleoptera, five to the order Diptera and three to the order Hymenoptera. Syrphid flies and *Xanthogramma* frequently visit citrus trees, especially their sunny parts. Both sexes of *Xylocopa* are effective pollinators of citrus flowers. The nectar gathering honeybee spends more time in visiting the flowers than the pollen gathering honeybee. The former prefers the uncompletely opened flowers and is active earlier in the day than the latter.

The clover pollinators are sixty-nine in species, four of which belong to the order Lepidoptera, sixteen to the order Coleoptera, fourteen to the order Diptera

and thirty five to the order Hymenoptera. The coleopterous insects visit the clover crop more than any of the other studied crops. *Colias croceus* and *Cosmolyce baeticus* are abundant on clover racemes. The latter is more effective as a pollinator than the former.

The beetles which visit the clover flowers, bite the anthers and feed on the pollen grains. With the exception of *Tropinota squalida* and *Ptosima undecimmaculata* they do not injure the flowers. The bodies of *Attagenus* sp. and *Anthrenus* sp. are covered with hair which helps them in carrying pollen grains from one flower to another.

Since the bodies of the insects which belong to the families Ichneumonidae and Chrysididae are not structurally adaptable of carrying great quantities of pollen, therefore they are not dependant pollinators.

Of the wild bees, the megachiles are effective pollinators as they are capable of carrying large quantities of pollen grains. *Anthidium* sp. has no special apparatus for collecting or carrying pollen. *Andrena* spp. are more effective in pollination than *Anthidium* sp. as they gather pollen and pack it in pellets. *Halictus* spp. and *Osmia* spp. are less effective in pollination. Both sexes of *Xylocopa aestuans* visit the flowers and gather nectar and pollen grains.

Both nectar and pollen gathering honeybees are effective pollinators of clover. In searching for nectar the honeybee comes in contact with the anthers and its body is covered with pollen. Nectar gathering takes place in the morning while pollen gathering begins from about 11 a.m. to the end of the day. The honeybee fixes itself to a certain area of the crop.

Cotton pollinators are fifty-eight in species, two of which belong to the order Lepidoptera, one to the order Diptera and fifty five to the order Hymenoptera. While searching for nectar, *Pelopidas borbonica* and *Earias insulana* come in contact with the anthers and their bodies are covered with pollen. *Anthrax* sp. is the only fly which visit cotton flowers. The small quantity of hair on its body enables it to carry pollen grains. The insects which belong to the families Chrysididae and Sphegidae are not structurally adaptable for carrying great quantities of pollen. Ants visit the flowers to feed on nectar secreted from the floral and extra-floral nectaries. Their bodies are incapable of carrying large quantities of pollen grains. Of the wasps, *Scolia* spp., *Cyphononyx flavicornis* and *Mutilla interrupta* carry moderate quantities of pollen grains. *Anthophora quadrifasciata* and *A. savignyi* visit the flowers to gather nectar and pollen grains. Both sexes of the carpenter bee visit the floral and extra-floral nectaries. The female of this insect usually gathers pollen grains.

Wild bees are more effective in pollination of cotton flowers than wasps. The honeybee visits the flowers to gather both nectar and pollen grains. The nectar gathering honeybee often prefers to visit the extra-floral nectaries which have more concentrated sugar. While the pollen gatherer comes in contact with the staminal tube its body becomes covered with pollen grains.

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SOME OBSERVATIONS ON THE BEHAVIOUR OF THE EGYPTIAN LOCUST, *ANACRIDIUM AEGYPTIUM* L.

[*Orthoptera : Acrididae*]

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INTRODUCTION

The genus *Anacridium* is common in Africa, South and South-West Asia, but the species *aegyptium* L. is known to be confined to the areas around the Mediterranean Sea and frequently observed in Egypt.

Scattered individuals of *A. aegyptium* L. are widely distributed throughout the Nile Valley up to Qena Province, in desert valleys near the Nile and in coastal plains of the Western Desert.

This insect is commonly observed in cotton cultivations and orchards. It is easily recognized, among other Acridiidae in Egypt, by its size and colour. The adults is brownish with a dark areola on the hind wings. The hoppers are generally green with a distinct three striped curved-pronotum, but they acquire in a short time the colour of their surroundings.

ECONOMICAL IMPORTANCE

Anacridium aegyptium does not usually cause noticeable damage in Egypt and it is considered a minor pest. On two occasions, however, during the last thirty years its numbers increased to a dangerous extent and endangered the crops. The first was in 1927-1928 in Assyut Province and in Ameriyah (Mariut); the second, again, in the Assyut Province in 1951-1952.

This increase in the number of insects is generally attributed to the prevalence of favourable weather conditions over a period of two or more successive years

with significant reduction in mortality. *Anacridium aegyptium* is susceptible to low temperatures which increase the percentage of mortality. A warm winter, on the other hand, reduces considerably adult mortality with a consequent increase in the number of spring survivals and a more rapid increase in summer population.

In severe infestation, cotton plants suffer greatly from hoppers which damage not only the leaves but also branchlets, bark and even cotton bolls. In orchards, despite the preference of adults to leaves, other parts of the trees and even the fruits are liable to attack. It was observed that in severe infestations, adults left only the seeds in feeding on fruits of grapes, guava, dates and pomegranate; while in feeding on citrus trees they only touched cracked fruits. In mixed orchards, where there are more than one kind of fruit trees, it was noticed that adults preferred feeding on pome trees, then citrus and mango trees; banana, custard-apple and olive trees were not seriously affected.

BEHAVIOUR IN THE FIELD

Hoppers and adults of the Egyptian Locust are slow, inactive and are not easily disturbed as compared with the Desert or Migratory Locust. This is because of their perpetual living on plants and trees from which they scarcely descend on the ground save for oviposition.

Adults hibernate on tall plants and trees in agricultural and desert areas. Early in spring, they return to the fields and disperse on winter crops and later on cotton cultivations. Copulation could be seen on a general scale during March and April. Oviposition takes place generally in cotton fields but early oviposition may occur in winter crop fields, and it was observed to last up to June.

In general, hatching happens during May and June. Early hatching may occur in April on a small scale. Hoppers concentrate in cotton fields after the removal of winter crops.

Adults appear from July but mostly in August and September. Later they appear as congregations, somewhat condensed in orchards or tall plants fields after leaving their breeding places.

Anacridium aegyptium completes one generation in a year under natural conditions.

Observations on behaviour and movements of this species, in laboratory and in field, do not indicate gregarious habits. Current experiments failed to show the peculiar conspicuous characters common in migratory locusts. E/F ratio differs with specimens collected from one area, and from different localities which is most probably due to environmental conditions and not to gregariousness.

Informations gathered as well as observations on the movements of *Anacridium aegyptium* indicate merely the movement of the insects due to agricultural operations — from its breeding places to adjoining more suitable sites. In the Nile Valley, breeding generally occurs in cotton fields. The picking of cotton and the removal of its stalks, during October and November, results in the movement of the insects — which would be, by then, all adults — to neighbouring trees and to fields planted with tall plants such as maize and sugar-cane. In Upper Egypt, adults move to neighbouring sites with the inundation of breeding fields which begins about September. Scouting of desert valleys near the Nile, namely Wadi Assyuti and Wadi Qena, during the last period of multiplication (1950-1951), indicated the occurence of normal local breeding in those places. This breeding might be augmented by adults from adjacant agricultural areas where ecological conditions became unfavourable (1).

Individuals of *Anacridium aegyptium*, which appear with Desert Locust swarms (2), are likely because of the breeding of the two species in the same area (3) and some of *Anacridium* adults accompanied the flight.

The previous review elucidates some of the factors initiating the movement of *Anacridium aegyptium* L. from one area to another and which seems to be ecological rather than being related to physiological instinct or to gregariousness in its specific meanings.

DAILY BEHAVIOUR UNDER NATURAL CONDITIONS

The following observations on the daily behaviour of *Anacridum aegyptium* were taken out of doors in the big cage of the Locust Research Sub-Section. This cage has a size of $17 \times 11 \times 2.25$ metres with walls and ceiling of wire gauze. It was cultivated with scattered small trees of *Eucalyptus*, *Lycium* and *Melia*.

More than 10,000 of *Anacridium aegyptium* adults were put in this cage. Daily observations were recorded from early morning at sun rise until sun set, during the last period of multiplication, and continued for about four months from

(1) In a report submitted to the Ministry of Agriculture on 5.2.1952 by Mr. N. B. Nakhla, Senior Entomologist, on scouting of Wadi Assyuti during January 1952, it was stated that the number of adults found, and the high mortality observed did not exceed those seen recently in one of Assyut's orchards and their numbers were diminishing as going far from the Nile Valley.

(2) Mr. M. S. El-Zoheiry, ex-Director of Plant Protection Department, stated in a report submitted to the Fourth International Locust Conference (Cairo, 1936) that during 1929 Desert Locust invasion of Egypt, the swarms contained 25% of *Anacridium aegyptium* L.

(3) During the Desert Locust Campaign in Egypt (1948), hoppers of the two species, *Schistocerca gregaria* F. and *Anacridium aegyptium* L., were found breeding together in the coastal plains of the Western Desert.

January to April 1952. Temperatures of open air (A), between tree branches (T) and solar radiation (S.R.), were taken at times to indicate the observed stage of activity. Relative humidity (R.H.) was also recorded.

During the period of observations, degrees of temperatures and relative humidity ranged as follows:

(A) 2.5 to 34°C.; (T) 2.5 to 33°C.; (S.R.) 3 to 55°C.; (R.H.) 55 to 100%.

Observations on the daily behaviour could be summarised in accordance with degrees of temperatures and relative humidity as follows:

Stage I : Immobility during night and dawn

At low temperatures, adults spend the night motionless on trees and tall plants. They take refuge in the inner parts under the leaves and do not show any sign of movement. This state is caused by cold and affected by absence of light. It was noticed that the insects were in cold stupor at temperatures: (A) 2.5°C., (T) 2.5°C. and (S.R.) 3°C.

Stage II : Movement of extremities

In the early morning, with the gradual rise of temperature and sunshine, the insects start their motion by moving their hind legs and antennae. The hind legs extend and rejoin in a slow motion. They may move slightly and change their resting places but still maintain their posture under leaves in trees or plants.

This stage was observed at degrees ranging as follows: (A) 3.5 to 7°C.; (T) 3.5 to 7°C.; (S.R.) 4 to 6°C.; (R.H.) ranged from 71 to 85%.

It it is cloudy, this stage continues to (A) 8°C., (T) 8°C. and (S.R.) 12°C. If it is also foggy it lasts to 10, 10 and 12°C., respectively.

Stage III : Beginning of movements

With increase of temperature, adults begin their movements. They appear on leaves and crawl eastwards towards the warmside of the trees. All these movements take place between branches and few insects emerge on the surface of trees.

Movements among branches of trees was observed at temperatures ranging as follows: (A) 7 to 9°C., frequently at 9°C.; (T) 7 to 8°C.; frequently at 8°C.; (S.R.) 6 to 12°C., frequently at 12°C.; (R.H.) ranged from 55 to 74%.

If the sky is clouded, this stage continues to 11.5, 11.5 and 15°C., respectively. In addition to cloudiness, if it is also dewy the progress to the next stage is delayed to (A) 14°C., (T) 13°C. and (S.R.) 22°C.

Stage IV : Emergence on the surface of trees and plants

At the following temperatures, it was observed that most of the adults appeared on the eastern sunny surface of trees and plants: (A) 11 to 17°C., frequently

at 15°C.; (T) 8 to 16°C., frequently at 13°C.; (S.R.) 22 to 32°C., frequently at 32°C.; (R.H.) ranged from 57 to 83%.

It was also noticed that some of the insects which were sheltering on the lower branches of trees dropped on field crops.

Stage V : Dispersal

In this stage, adults remain for some time exposing their bodies to direct sun heat (basking) and then begin to disperse and spread on crops to proceed with their normal activities.

Insects start the process of dispersal at temperatures as follows: (A) 13 to 19°C., frequently at 18°C.; (T) 13 to 18°C., frequently at 17°C.; (S.R.) 30 to 41°C., frequently at 35°C; (R.H.) ranged from 52 to 81%.

During this process, if it happens that the sky becomes clouded and solar radiation heat falls to a remarkable extent, the adult's activity subsides. But even in a cloudy weather with solar radiation heat about the optimum, the insects proceed with their activities.

The adults, in exposing their bodies to direct sun heat, select the warmest places. In doing so, they either remain on trees or disperse on crops; thus, they appear as scattered congregations in sunny places over the fields. In this act of sunning, the adults stand motionless in a horizontal position with sun rays, facing the sun with their whole bodies bent slightly so that every portion of it could be exposed to sun heat. Basking lasts for a period sufficient to achieve the required warmth for starting their normal activities.

Basking process was observed at temperatures as follows: (A) 16 to 24°C., frequently at 21°C.; (T) 15 to 23°C., frequently at 20°C.; (S.R.) 37 to 45°C., frequently at 40°C.; (R.H.) ranged from 64 to 82%.

Stage VI : General activity

As soon as the temperatures reach adequate degrees for normal activities, the insects proceed with feeding, moving, flying from one place to another, etc.

These activities were seen at the following temperatures: (A) 19 to 28°C., frequently at 24°C.; (T) 18 to 26°C., frequently at 23°C.; (S.R.) 38 to 50°C., frequently at 40°C.; (R.H.) ranged from 64 to 91%.

The behaviour of adults during this stage is intensified by further rise of temperature. It was observed that when temperatures, especially solar radiation heat, reaches higher degrees, the insects show a degree of restlessness which would be obvious in their continuous flying from one place to another; those on plants or trees avoid direct sun heat by hiding between branches. It was noticed that this did not affect the insect's ability for feeding. This restless attitude was observed

when (S.R.) heat exceeded 50°C. and also when open air temperature exceeded 30°C. with (S.R.) heat more than 40°C. as in the following cases :

A	T	S.R.	R.H.
26°C.	25°C.	52°C.	84%
28°C.	26°C.	53°C.	67%
30°C.	28°C.	55°C.	64%
31°C.	30°C.	44°C.	81%
32°C.	30°C.	55°C.	85%
34°C.	33°C.	40°C.	79%

Stage VII : Returning to shelter

In the afternoon, when temperatures fall, especially solar radiation heat, the adult's activity subsides. The insects begin to return to their night sheltering places, crawling or flying, without ceasing their feeding or movements. Clouds also hasten this process.

Returning to shelter in general was observed at temperatures ranging as follows: (A) 25 to 17°C., frequently at 23°C.; (T) 24 to 16°C., frequently at 21°C.; (S.R.) 32 to 25°C., frequently at 25°C.; (R.H.) ranged from 74% to 91%.

It was observed that more than 95% of the adults were on tall plants and trees at the following temperatures: (A) 19/18°C., (T) 19/18°C. and from 26 to 19°C. (S.R.), (R.H.) ranged from 67 to 100%.

Stage VIII : Cessation of feeding

This is the second act which the adults perform on their course towards night repose. The number of insects which feed decrease gradually corresponding with fall of temperature. In this stage, in spite of cessation of feeding, the adults still sustain the power for limited movements. They could be seen between branches seeking suitable places to spend the night.

At temperatures ranging as follows, it was observed that the insects ceased feeding: (A) from 22 to 13°C., (T) from 22 to 13°C., (S.R.) from 25 to 18°C., (R.H.) ranged from 80 to 100%.

In some cases, very few individuals were seen feeding at low temperatures as (A) 12°C, but (S.R.) heat was always above 22°C.

Stage IX : Immobility

With the continuous fall of temperatures and night fall, the insects seek refuge in the inner parts of the trees and plants under leaves. They stay motionless, but their extremities cease moving when the temperature drops to lower degrees.

More than one factor interfere and contribute to this stage, such as clouds, absence of light, night fall, winds and high humidity. All collaborate with low temperature in producing this state.

The minimum degrees of temperatures at which insects were seen to cease movements were : (A) 12°C., (T) 12°C., (S.R.) 12°C., (R.H.) was 87%.

OTHER OBSERVATIONS ON THE DAILY BEHAVIOUR

(1) In rainy or dewy days and during intervals before and after periods of general activities, insects often flap their wings for about 1 to 2 minutes while settling in their places.

(2) Despite the fact that the insects are not easily disturbed and could be easily caught especially while copulating, it was noticed that when (S.R.) heat exceeded 40°C. they became susceptible to disturbance.

(3) In early stages of activity (stages 2 and 3), the insects which are sheltering on leaved plants and trees, start their movements earlier than those on leafless plants or in bare places. Also their activities in the evening continue to later hours. In this respect, adults prefer sheltering in leaved trees.

(4) Fluctuation of climatic conditions effect the adult's behaviour. Clouds and rain delay the progress of activity in the morning and hasten the sheltering in the afternoon. Adults avoid wind while proceeding with their activities.

PRACTICAL DEDUCTIONS

(1) In the years of recession, survey of hibernating places (orchards and fields planted with tall plants) and keeping the insects congregations under control in their relatively restricted areas, reduce the infestation during the ensuing year.

(2) In spring and summer, chemical control measures against other pests, especially the cotton leaf worm, has its effect on the hoppers population.

(3) Due to the fact that *A. aegyptium* L. is phytophilus, the methods applied in its control should be limited to dusting and spraying and not baiting which proved to be useless.

(4) Dusting and spraying when applied — during control operations — before and after the stages of dispersal and general activity, reduce control expenditure.

(5) The relation between weather conditions and fluctuation of population of this pest is still under investigation.

SUMMARY AND CONCLUSIONS

At temperatures below an open air temperature (A) of 3.5°C., between tree branches temperature (T) of 3.5°C. and solar radiation temperature (S.R.) of 4°C., adults of *A. aegyptium* spend the night motionless on tall plants and trees, in inner parts covered by leaves. They suffered a stupor at (A) 2.5°C., (T) 2.5°C., and (S.R.) 3°C.

Early in the morning, with the rise in temperature and increased sunshine, they start their movements at temperatures (A) 3.5°C.,(T) 3.5°C.,(S.R.) 4°C.,by moving their hind legs and antennae. Up to (A) 7°C., (T) 7°C., (S.R.) 6°C., slight movements of adults and occasional change of roosting places might take place.

With further rise of temperature, at about (A) 9°C., (T) 8°C., (S.R.) 12°C., adults start moving eastwards towards sunshine and most of them appear on the surface of trees and plants at about (A) 15°C., (T) 13°C., (S.R.) 32°C.

At temperatures about (A) 18°C., (T) 17°C., (S.R.) 35°C., they start spreading on crops where they remain basking for some time before starting with their normal activities. In the sunning process, which takes place at temperatures about (A) 21°C., (T) 20°C., (S.R.) 40°C., adults appear as scattered congregations in the fields.

Normal activities, i.e. general feeding, flying and moving, take place at temperatures about (A) 24°C.,(T) 23°C., (S.R.) 40°C. If it happens—during this process—that (S.R.) exceeds 50°C., or open air temperature exceeds 30°C. with a minimum of 40°C. (S.R.,) adults become restless and avoid direct sun heat.

In the afternoon, with the decrease in temperatures — especially of (S.R.) — adults crawl or fly to their sheltering places at temperatures about (A) 23°C., (T) 21°C., (S.R.) 25°C.. Most of the adults would be on their roosting places at about (A) 19°C., (T) 18°C., (S.R.) 26-19°C.

Adults cease feeding at lower temperatures at (A) 13°C., (T) 13°C., (S.R.) 18°C. and seek refuge in inner parts of trees and plants.

All movements were observed to cease at temperatures (A)12°C., (T) 12°C., (S.R.)12°C. This is due to the combined effects of several factors including absence of light and low degrees of temperatures.

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LARIOPHAGUS DISTINGUENDUS FÖRST.

[*Hymenoptera : Pteromalidae*]

ECTOPARASITE ON *RHIZOPERTHA DOMINICA* FAB.

[*Coleoptera : Bostrychidae*]

(with 12 Text-Figures)

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I. Introduction. — II. Material and methods. — III. Biology of *Rhizopertha dominica* Fab. (1. Habits; 2. Female reproductive system; 3. Fecundity: 4. The life-history). — IV. Biology of *Lariophagus distinguendus* Först. (1. The life-history; 2. Oviposition; 3. Drumming and drilling responses; 4. General analysis of the behaviour pattern; 5. The parasite host ratio).—V. Discussion — VI. Summary. — VII. References.

I. INTRODUCTION

The lesser grain borer, *Rhizopertha dominica* Fab., is one of the serious store-house pests. Detailed work concerning the life-history and habits of this insect in America has been done by CHITTENDEN (1911) and SCHWARDT (1933). Its occurrence in India as an injurious pest of grains was shown by BARNES and GROVE (1916). An account of its geographical distribution as well as a comparative description of its larval instars was given by POTTER (1935). Oviposition, olfactory conditioning and host selection was considered by CROMBIE (1941 and 1943).

GOODRICH (1921) stated that *Lariophagus distinguendus* Först. attacks *Rhizopertha dominica* Fab. together with *Calandra granaria* L. and *C. oryzae* L. *Lariophagus distinguendus* Först. is chiefly a parasite of *C. granaria* and *C. oryzae* (HASE, 1920 and 1924). POTTER (1935), LEPESME (1945) and KASCHEF (1955) recorded *L. distinguendus* as one of the natural enemies of *R. dominica*. KASCHEF (1954 and

1955) studied in detail the biology and habits of *Lariophagus distinguendus* Först. It was found, contrary to the opinion of VAYSSIÈRE (1901), that *Lariophagus* is an ectoparasite on *Stegobium paniceum* L. The author (1955) could also rear *L. distinguendus* as an external parasite on *Ptinus tectus* Boield. (Coleoptera: Ptinidae) for the first time.

The aim of the present work is to investigate the mode of life and type of parasitism of *L. distinguendus* on *R. dominica*. It is also hoped to obtain some information on the oviposition behaviour of *L. distinguendus*. A brief account of the fecundity, the duration of the life-history under controlled conditions, and the number and duration of the larval instars of the host is given.

A difficulty that previously handicaped the study of this problem was the hardness of the grains inside which *Rhizopertha* lives. "Semoule de blé" was utilised as food for the host by the author for the first time.

I should like to thank Prof. Dr. P. P. GRASSÉ of the Evolution Laboratory (Paris) in whose laboratory the work has been started, Prof. Dr. A. KOCH of the Zoology Institute (München) for his interest in this work and Prof. Dr. T. SAYED of the Faculty of Science (Cairo, Abbassieh) for his criticism and continuous encouragement.

II. MATERIAL AND METHODS

Three samples of grain-reared *Rhizopertha dominica* Fab. were obtained from three different countries; the first from the Laboratoire d'Évolution des Êtres Organisés (Paris), the second from the Paul Buchner-Institut für experimentelle Symbioseforschung, Zoologisches Institut (München), and the third from the Entomological section, Ministry of Agriculture (Cairo). The beetles were reared on millet (*Sorghum durra*), wheat and "semoule de blé" with the commercial name "Heudebert", in the manner described by KASCHEF (1955).

Most of the cultures were kept at 26 ± 0.5°C. and $70\pm5\%$ R.H. Certain experiments and some cultures were carried out or kept at room temperature (19°C. and 35% R.H., in the average).

The millet, wheat or "semoule de blé", before use were sterilised and brought into equilibrium with the required humidity.

The female genital system can be pulled out of ether killed *Rhizopertha* by pulling the hidden last tergite with fine forceps. The ovaries are less likely to break during pulling, if the insect is held in water.

To distinguish the sex, *Rhizopertha dominica* Fab. was removed from the cultures in the pupal stage.

III. BIOLOGY OF *RHIZOPERTHA DOMINICA* FAB.

1. Habits

R. dominica has been reported on a wide variety of foods, chiefly cereals. Its habit of feeding on stored grains and similar starchy products has rendered it

economically very important. It is considered as a major pest in India, the Argentine, the United States of America and New South Wales.

Grains badly attacked by the beetles may be hollowed out until a thin shell remains. Several beetles may be found in one grain of millet; more than four have been frequently found in a grain of wheat. The beetle is capable of attacking the grain only in the first larval stage; the older stages are not powerful enough to penetrate the loose grains owing to their permanently flexed postures and their limited power of locomotion.

The eggs are generally laid in batches on the surface of the grains to which they are firmly cemented. Very rarely, separate eggs are found attached to the floor or the walls of the breeding jars or found among the frass produced by the insect. A favourable place for oviposition on the millet grain is at the pointed embryo and underneath the paleae.

The young beetle after shedding the pupal skin spends about one week inside the grain. The adults leave the grains in a fully mature condition and copulation takes place soon after that. It seems also that the beetles fast for some days after emergence but start to feed before laying eggs.

2. Female genital system

A *Rhizopertha dominica* female has two ovaries (Fig. 1) each of which has 8 ovarioles. The ovarioles of each side join to form the lateral oviduct. The two

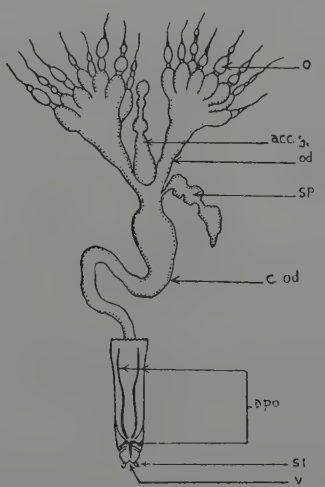

FIG. 1: *Rhizopertha dominica* Fab., female genital system (*O*, ovariole; *od*, oviduct; *c.od*, common oviduct; *acc.gl.*, accessory gland; *sp.*, spermatheca; *apo*, two pairs of apodemes; *st*, stylus with a bristle; *V*, vulva). — × 30.

lateral oviducts join to form the common oviduct which is continuous with the vagina. The spermatheca and an accessory gland open into the common oviduct.

3. Fecundity

Two series of experiments were conducted to study the average number of eggs laid per female, one at room temperature (19°C. and 35% R.H., in the average) and the second at a constant temperature of 26°C. and a relative humidity of 70%. This was accomplished by isolating pairs of one male and one female each, in small Petri dishes of 3 × 1.3 cm. containing small quantities of a mixture of conditioned millet and "semoule de blé". In each series of experiments thirty pairs were used. The adults used were always newly hatched and the eggs were removed and counted daily.

In the first series of experiments carried out at normal conditions of temperature and humidity, the total number of eggs laid per female ranged between 34 and 183 with an average of 72±4.4. In the second series of experiments conducted

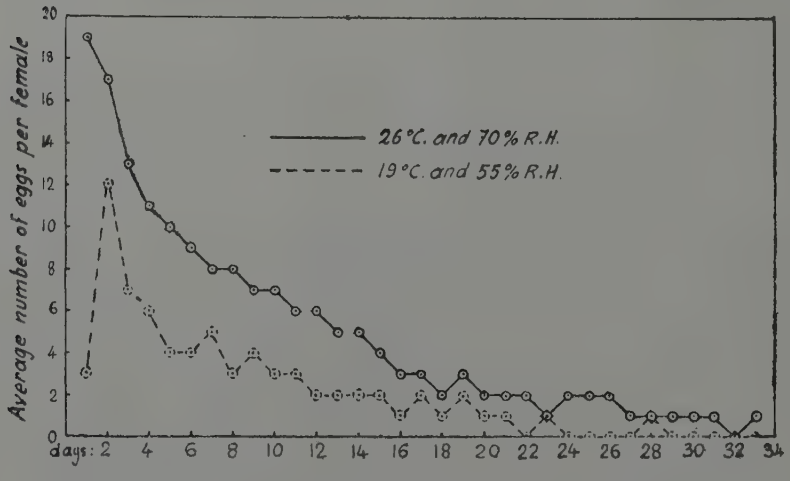

FIG. 2: Rate of oviposition of *Rhizopertha dominica* Fab. at two different conditions of temperature and humidity.

at controlled conditions of temperature and humidity it ranged between 51 and 279 with an average of 165±6.8. Figure 2 shows that the oviposition rate was maximum on the first or second days, then it decreased gradually as the females advance in age.

TABLE I

Fecundity of Rhizopertha dominica *Fab*

Temperature and Relative Humidity	Number of observations	Total number of eggs laid per female	
		Range	Mean
19°C. and 35%.....	30	34-183	72±4.4
26°C. and 70%.....	30	51-279	165±6.8

4. The life-history

The EGG: When first laid, the egg is glistening and white; later it darkens and wrinkles appear on the surface. It is almost cylinderical, gently rounded at one end and somewhat pointed at the pedicel end (Fig. 3). The average length of the egg is 0.58 mm. and their diameter 0.21 mm.

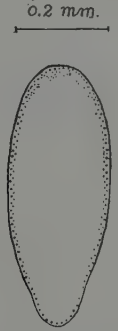

FIG. 3 : Egg of *Rhizopertha dominica* Fab.

Some days before the egg hatches, the young larva becomes coiled up and its brownish head can be seen through the transparent egg shell. Under natural conditions (19°C. and 35% R.H., in the average) the egg hatches within 11 to 20 days with an average of 16 days. At 26°C. and 70% R.H., the incubation period is shorter, ranges between 5 and 15 days with an average of 9 days.

The LARVA: The larva of *Rhizopertha dominica* Fab. has been recorded by CHITTENDEN (1911), LESNE (1924, b) and GARDNER (1933). A complete description of the morphology was given by POTTER (1935).

On hatching the first stage larva bores directly into the millet grain. It is scarabaeiform but not recurved. The head is exserted but becomes gradually retracted into the thorax in the succeeding stages.

The larva is white, slightly yellowish towards the head. There are usually four ocelli on each side of the head, three of them are arranged in a triangle which

is situated dorsally, while the fourth ocellus is somewhat below and ventral in position. However, the number of ocelli is variable; this has also been observed by POTTER (1935). In the last larval stage the ocelli are reduced and retracted in the posterior edge of the prothorax. The legs are tolerably long, slightly yellowish with long claws. The legs and thorax bear laterally hairs which are relatively shorter than those which cover the sides of the abdomen. The last abdominal segment has on the dorsal surface a median curved spine which is directed backwards. The first thoracic and the first eight abdominal segments bear spiracles.

In the last stage, the larva (Fig. 4) is recurved and uncapable of locomotion. The antennae are 2-segmented and inserted at the sides of the head capsule. The body is covered with short hairs, the body segments 5, 6, 7 and 8 are much extended and the end of the abdomen shows a well marked anal furrow.

FIG. 4: Mature larva of *Rhizopertha dominica* Fab., × 45.

Like most other graminivorous insects, the larval and pupal stages are spent inside the grains rendering it considerably difficult and sometimes impossible to determine the duration of the developmental stages. POTTER (1935), mentioned 4-5 larval stages. The number obtained by breeding newly hatched larvae in a mixture

TABLE II

Number and duration of the larval instars of Rhizopertha dominica *Fab. bred at 26°C. and 70% R.H.*

Larval instar	Number of larvae measured	Mean width of head cap. (mm.)	Mean duration in days
First	189	.1281 ± .0381	17
Second	210	.1702 ± .0288	12
Third	200	.2597 ± .0076	10
Fourth	200	.4036 ± .0085	10
Fifth	215	.4769 ± .0352	8
Larval stage			57

of "semoule de blé" and broken millet at 26°C. and 70% R.H. was five, with mean duration of 17, 12, 10, 10 and 8 days, respectively. This was accomplished by five moults of which the fifth occurs on changing to pupa.

The PREPUPA: At the end of the larval stage, the insect straightens out and the abdomen is no longer curved ventrally. The head protrudes from the prothorax and assumes a vertical position to the long axis of the body. The ocelli are lost and the insect is more or less incapable of movement. At a constant temperature of 26°C. and relative humidity of 70%, the prepupa is changed to pupa in 1-2 days.

The PUPA: The pupa is elongated, at first it is white in colour and later brown pigment appears in the eyes followed by the mandibles. It is about the same size of the adult and the dorsal surface is covered with hairs.

The chief characteristic of the pupa is that sexual dimorphism is manifested at the posterior end of the abdomen (Fig. 5). This is of some importance since only in the pupal stage it is possible to distinguish the sexes easily. The duration of the pupal stage is 7-8 days at 26°C. and 70% R.H.

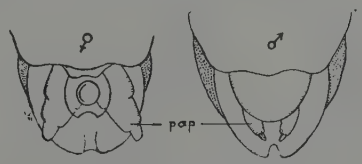

FIG. 5: *Rhizopertha dominica* Fab., posterior tip of the abdomen of the pupa showing sexual dimorphism (female pupa (left) : *pap*, three jointed papilla; male papilla (right): *pap*, two jointed structure). — × 80.

IV. BIOLOGY OF *LARIOPHAGUS DISTINGUENDUS* FÖRST.

Lariophagus distinguendus Först. is one of the most important chalcid parasites which can easily be bread in the laboratory. Its economic importance comes from the fact that it usually attacks stored-grain pests.

1. The life-history

The female *Lariophagus* drills with ovipositor through the puparium (1) of *Rhizopertha dominica* Fab. and usually lays one egg on the enclosed prepupa (Fig. 6). After the egg has been laid it hatches into a larva in 1-2 days at 26°C. and 70% R.H. The newly hatched larva is mobile; it crawls on the host body for two to three hours, sometimes more, until it succeeds in piercing the host skin and starts

(1) For the sake of convenience the term "puparium" is used although we are dealing with a simple larva, prepupa or pupa resting in a cavity of a wheat or millet grain or made of agglomerated granules of "semoule de blé".

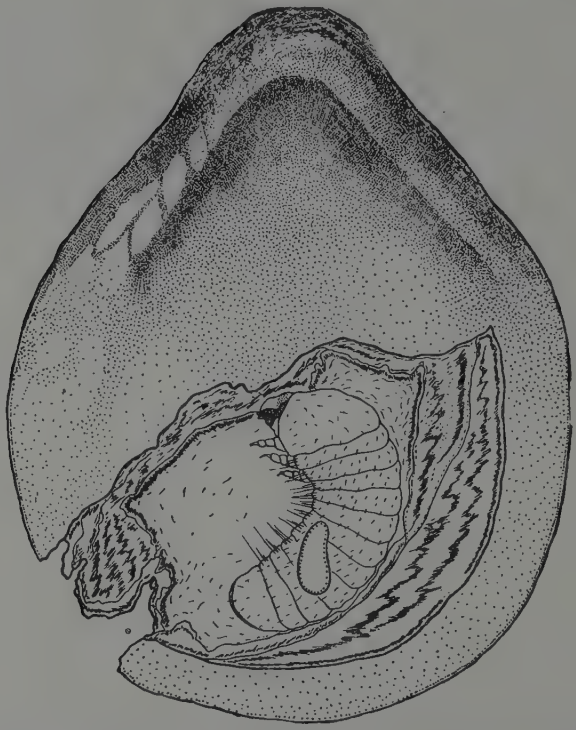

FIG. 6: Prepupa of *Rhizopertha dominica* Fab. carrying an egg of *Lariophagus distinguendus* Först. inside a millet grain (greatly enlarged).

to feed. The larva sucks its host from the exterior. It grows gradually and the body segments become distended (Fig. 7). After seven to eight days, at 26°C. and 70%

FIG. 7: Larva of *Lariophagus distinguendus*. Först sucking a prepupa of *Rhizopertha dominica* Fab. — × 32.5.

R.H., the larva pupates. The duration of the pupal stage under the same conditions is 11 days. The total duration of the development on *R. dominica*, at 26°C. and 70% R.H. is 20 days, in the average; it is more or less similar to that obtained by using *Stegobium paniceum* L. or *Ptinus tectus* Boield. as hosts (Fig. 8).

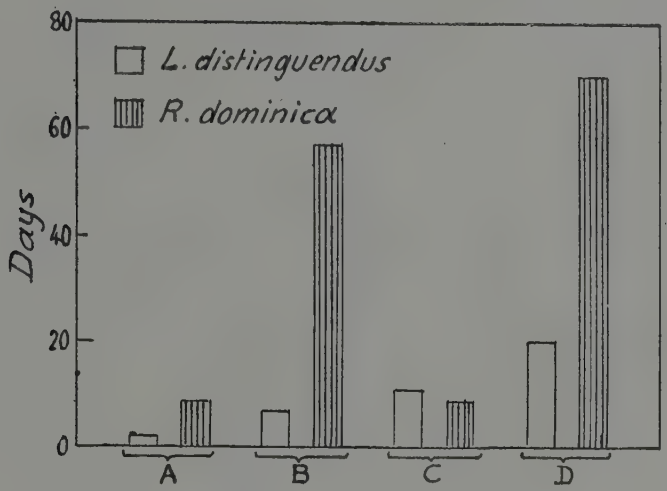

FIG. 8: Duration of life-history of *Lariophagus distinguendus* Först. and *Rhizopertha dominica* Fab. at 20°C. and 70% R.H. (*A*, incubation period; *B*, larval stage; *C*, pupal stage; *D*, total duration of life-history).

Experiments carried out using aged larvae, prepupae and young pupae of *R. dominica* (French sample) showed that, the female *L. distinguendus* prefered the prepupae for laying its eggs. Thirty newly emerged females of *Lariophagus* were introduced each in a Petri dish 6×1.5 cm which contains 12 puparia of larvae, prepupae and young pupae of *Rhizopertha*. The experiments were conducted at 26°C. and 70% R.H. After four days the females were removed and the puparia were investigated. Of the 360 puparia, 291 were parasitised. Of the infested puparia, 213 were containing prepupae of *Rhizopertha*. Two other series of experiments, in each of which 20 females of the parasite were used, were also carried out. In one series of experiments a German sample of the host was used and in the other an Egyptian sample. The females of *Lariophagus* again payed little attention to the larvae or pupae and prefered the prepupae. The results obtained from the three series of experiments are summarized in Table III which clearly shows that, given a choice between larvae, prepupae and pupae of *R. dominica*, the prepupae are prefered by *L. distinguendus* (*see* Fig. 9).

The female of *L. distinguendus* usually lays one egg per host; the latter must be enclosed inside the puparium. Using prepupae of *St. paniceum* or *P. tectus* extracted from their grains, the female parasite died without laying. In an experiment, using *R. dominica* as a host, 8 prepupae extracted from the millet grains and 8 ones intact were placed together in a Petri dish and one parasite female was introduced. The dish was left in dark for 48 hours. All the intact prepupae were parasitised while all the exposed ones were neglected. This experiment was repeated ten times with the same result.

In more than two years during which this work was going on, it was never found more than one egg or one larva of *L. distinguendus* on *R. dominica*. The same fact was previously observed in case of *St. paniceum* and *P. tectus*. Exceptionally,

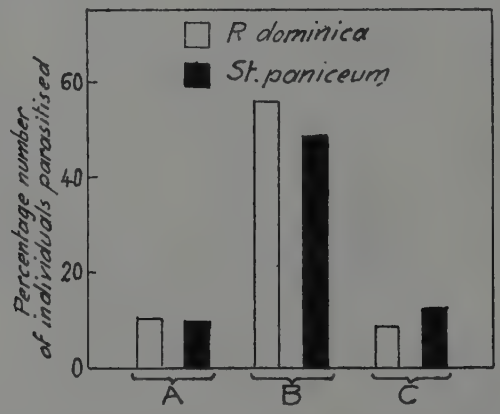

FIG. 9: Stages of *Rhizopertha dominica* Fab. and *Stegobium paniceum* L. parasitized by *Lariophagus distinguendus* Först. (*A*, mature larva; *B*, prepupa; *C*, pupa).

TABLE III

Stages of Rhizopertha dominica *Fab. parasitised by* Lariophagus distinguendus *Först. (26°C. and 70% R H)*

Host sample	Number used of		Number of individuals parasitised			
	L. distinguendus females	*R. dominica* puparia	Larvae	Prepupae	Pupae	Total
French	30	360	41	213	37	291
German	20	180	13	91	14	118
Egyptian	20	180	21	101	11	133
Total	70	720	75	405	62	542
Percentage: ...			10.3	56.2	8.5	75

under abnormal conditions such as the lack of the host or the favourable host stage, two or three eggs or larvae of the parasite were found on *St. paniceum* (KASCHEF, 1955).

2. Oviposition

HASE (1924) and KASCHEF (1955) studied in detail the different stages of the oviposition act in *L. distinguendus*. Here the aim has been to describe the behaviour pattern and attempt to discover the releasing stimuli which are operating at each stage.

The paired ventral valves of the ovipositor pierce the wall of the puparium and for 1-2 minutes enlarge the hole which they have made. The median dorsal valve is then inserted and the ovipositor is pushed straight down to its fullest extent. The parasite presses strong enough to indent the host's integument. A poisonous fluid is injected immediately before laying the egg. The ovipositor remains inserted for one to three minutes.

Immediately prior to oviposition the ventral valves are protruded a little and an egg appears between them and the median valve. The egg swells rapidly and assumes its characteristic shape in few seconds. The egg sticks to the ventral valves which are protruded to their fullest extent so that it is deposited on the host body. The ventral valves are then retracted and the ovipositor is withdrawn from the puparium.

The number of eggs found in a puparium of *R. dominica* was usually one and the number of mature eggs in the ovaries are not deposited at one time. Females dissected immediately after they have left a host may contain as many as 9 mature eggs.

3. Drumming and drilling responses

The experimental work on drumming and drilling responses was carried out at normal conditions of temperature and humidity (19°C. and 35% R.H.), using standard parasites and hosts. The investigation consisted of observing the behaviour of *Lariophagus* when presented with genuine or artificial puparia from which some of the normal characteristics had been removed. The experiments consisted of placing 6 puparia of the host of similar kind and size together with one female of the parasite in a Petri dish for three hours and making general notes on the parasite's behaviour. Each experiment was repeated several times using other host puparia and other females of the parasite.

(a) *Presence of live prepupae*

The presence of live prepupae inside the puparium does not provide the releasing stimulus. Parasites drill readily into parasitised millet grains even when suitable puparia are equally available. The parasites are apparently unaware of the contents of a puparium until they have drilled through it.

(b) *Shape*

The typical shape of a millet or wheat grain is not of itself the stimulus which releases the drumming and drilling responses. Plasticene moulded into the shape of a millet grain and oval or rounded models of paper never elicited a drumming or drilling response. When a prepupa is placed in such a way that a part of it is showing, the parasite' females rarely drum and soon leave. The artificial puparia are not accepted. Broken millet grains or "semoule de blé" puparia from which aged larvae, prepupae or pupae are extracted and arranged each in such a way that a convex surface is presented to the parasite were sometimes drummed but never drilled.

(c) *Size*

SALT (1935), stated that *Trichogramma evanescens* would attempt to drill into large false hosts in preference to small true hosts. EDWARDS (1924) found that *Mormoniella vitripennis* (Walker) prefers large fly puparia to small ones. *Lariophagus distinguendus* will always choose large puparia in preference to small ones, but it prefers small genuine puparia to artificial ones.

(d) *Moisture*

There is some evidence that moisture is important in eliciting the drumming response. Puparia which are heated gently so that the water is driven off, elicit no response; the parasites touch them with the antennae and walk away. Also boiled millet grains display some interest in preference to dry ones.

There is no doubt that the presence of moisture is important in eliciting the drumming response, but it is unlikely that this alone is the releasing stimulus. Damp millet grains are never drummed as readily as genuine puparia.

(e) *Chemical contact stimulus*

Millet grains containing *R. dominica* which had been washed in alcohol, or in caustic potash were not at first drummed by the parasites but after washing thoroughly in water drumming responses were again elicited though less strongly.

(f) *Rejection factors*

Certain factors which lead to the immediate rejection of a host are chemicals, water droplets on or among the grains, and the presence of a hole in the wall of the puparium. In the case of a puparium from which either a host or a parasite has previously emerged, the parasite will usually drum over the surface until the hole is reached and then may crawl inside. The hole made by the ovipositor of a previous parasite is apparently non-detectable but it may have some effect on the behaviour of another parasite.

4. General analysis of the behaviour pattern

The behaviour pattern is shown in Figure 10. When a female *Lariophagus* touches a puparium she may stop and mounts, or she may continue walking; but

if she stops and mounts she invariably drums. Drumming is not always followed by tapping with the tip of the abdomen but tapping with the abdomen is always followed by drilling, though this may be of short duration. Tapping is always preceded by drumming, and drilling is always preceded by tapping. Drilling is followed by insertion whenever the puparium could be pierced. When the parasite confronts some difficulty in making a successful drill, it stops after a few seconds and returns to drumming in a different part of the puparium. This may be repeated 2-3 times before the ovipositor is inserted. Insertion of the ovipositor is followed by oviposition, or by immediate withdrawal and abandonment of the puparium.

The various stages of the pattern are well defined and it is clear that at certain points which have been underlined in Figure 10, releasing stimuli are received. As a result of a stimulus received when the female parasite touches a puparium she stops, mounts and drums. Whilst during drumming, she receives a stimulus for drill-

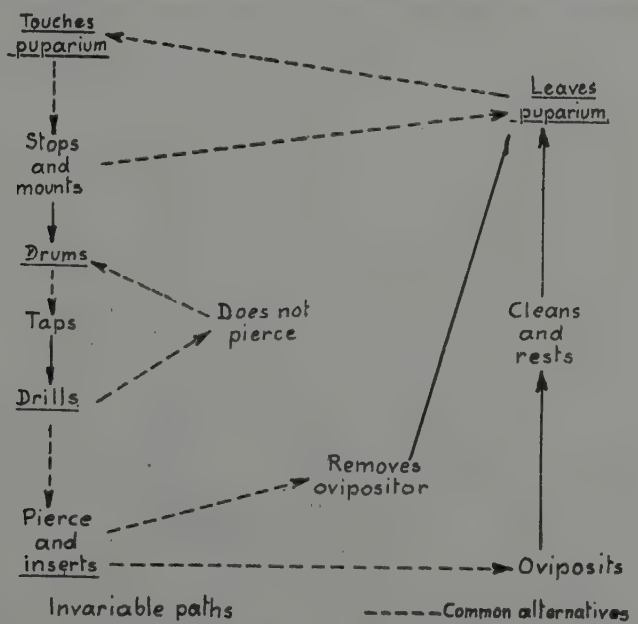

FIG. 10: The behaviour pattern of a *Lariophagus distinguendus* female from the time it touches a host puparium, showing the points at which stimuli are received (underlined).

ing. The intermediate action of tapping with the abdomen probably gives an orientation stimulus by which the tip of the ovipositor is inserted in the host body. This is a mechanical necessity as the surface of the puparium is so hard that the tip of the ovipositor slips unless it is supported in this way. After insertion, stimuli are received which lead either to withdrawal of the ovipositor or to oviposition.

There are therefore four distinct phases of behaviour:

(1) Findling the host area.
(2) Finding the puparium enclosing the host.
(3) Drumming and drilling response.
(4) Oviposition.

These phases are not arbitrary divisions of the behaviour pattern, but clearly recognizable stages. Finding the host area and the favourable host stage were considered in a separate paper published elsewhere (2). Drumming and drilling though separate actions, they are considered here together.

5. The host-parasite ratio

To find out the proportions of the host and parasite populations, the offspring of ten cultures kept at 26°C. and 70% R.H. was counted daily for one month. The total number of emerged *R. dominica* was 376 individuals (84.04%) of which

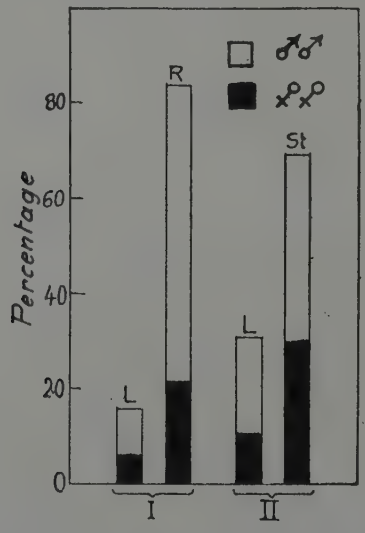

FIG. 11: Host/parasite ratio (I, populations of *R. dominica* Fab. and *L. distinguendus* Först. reared at 26°C. and 70% R.H.; II, populations of *St. paniceum* L. and *L. distinguendus* Först. reared at 24°C. and 45% R.H.).

278 were males and 98 were females with the percentage of 73.94 and 26.06, respectively. The parasite's offspring, on the other hand, was 66 individuals (15.96%) of which 39 were males (59.09%) and 27 were females (40.91%).

(2) Behaviour (1959).

It is evident, therefore, that the number of the host exceeded that of the parasite, the ratio being 7.003/1.32. The author (1955) showed that, in host-parasite cultures the number of *St. paniceum* L. exceeded that of *L. distinguendus* where the ratio was 2.22/1. The results obtained in both cases are represented in Figure 11.

V. DISCUSSION

A. — It is well known that parasitic-like phytophagous insects, display varying degrees of host specifity. Some are restricted to a single host species (monophagous), some attack a few species (oligophagous) and others attack a more or less wide range of species (polyphagous). The adoption of new hosts is fairly of a common occurance. There are many records of phytophagous insects attacking new food plants and in some cases, such as that of the Colorado Beetle, becoming major pests in consequence. Polyphagy is probably the primitive condition among parasitic and phytophagous insects.

The degree of polyphagy varies greatly and few attempts have been made as yet to define the term accurately or to distinguish it from oligophagy. DETHIER (1948) has proposed new definitions of the three terms as applied to phytophagous insects on the basis of chemical attractants in the food plants. In his scheme a monophagous insect is one which is attracted to plants containing one particular chemical or similar chemicals confused as one; an oligophagous insect is attracted by a few different chemicals which it can distinguish one from the other; a polyphagous insect is not particularly attracted by any chemical but accepts any plant which is not repellent by reason of chemical or physical characteristics. The scheme can be applied to certain phytophagous insects whose chemosensitivity has been analysed but not to the vast majority of phytophagous and to all parasitic insects. This limitation of using such well known terms leaves us with no *interim* terms of description for parasites or phytophagous insects whose host chemo-relations have not been worked out. It also excludes all other factors which operate in deciding the host range such as shape, movement, texture and colour of the host. DETHIER'S scheme is useful in itself but his definitions should be better if applied solely to types of chemo-behaviour.

The term monophagy has been used by other authors (e.g. ULLYET, 1936) to describe the behaviour of a parasite which attacks a single host genus although it attacks several species.

True monophagous insects are probably rare (IMMS, 1937). Oligophagy and polyphagy are of course relative terms and cannot be rigidly defined. However, it would be advantageous to reserve the former term for insects which attack closely related hosts, such as members of the same genus or family or any larger group with certain similarities in behaviour among its members. Polyphagy will then refer to the insects which attack completely unrelated species. In this paper it seems rea-

sonable to refer to *Lariophagus distinguendus* Först. as an oligophagous insect, since it selects hosts very similar in their feeding habits although they belong to different insect families.

B. — Some parasitic insects live externally on the host (ectoparasites) and some others live inside the host (endoparasites).

Usually, endoparasitism occurs when the host is free-living, as illustrated by the adult beetles attacked by the Euphomarinae and other groups. On the other hand, external parasitism generally occurs on hosts which live in confined quarters. Practically all the hosts attacked by *L. distinguendus* are enclosed inside puparia and the female *Lariophagus* never oviposits on uncovered hosts.

Hosts attacked by ectoparasites are usually permanently and completely paralysed. On the other hand, internal parasites temporarily paralyse their hosts. Prepupae of *St. paniceum* or *R. dominica* attacked by *L. distinguendus* are completely paralysed by the sting during the act of oviposition. The paralysed host never recovers.

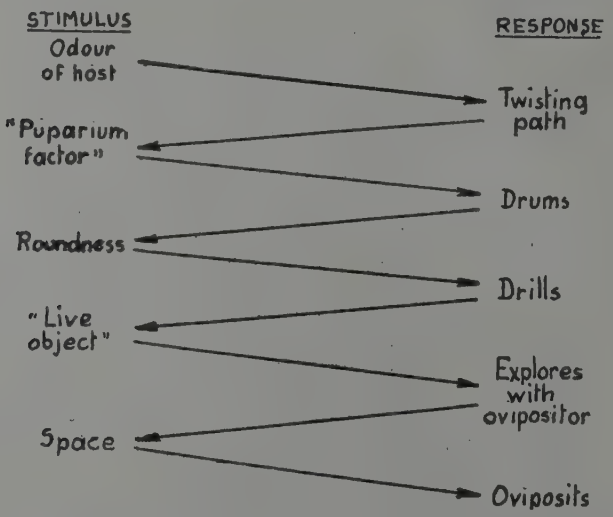

FIG. 12: A schematic arrangement of the reaction chain leading to oviposition in *L. distinguendus* Först.

Among the endoparasitic species the full amount of eggs to be laid is usually deposited at one insertion of the ovipositor, and often very quickly. Thus, the female of *Apanteles militaris* deposits up to 72 eggs at one insertion and the time required does not exceed one second (TOWER, 1915). However, *Apanteles sagax* Wlkn. which develops in considerable numbers in the caterpillars of *Sylepta derogata* F., deposits its eggs singly and at some distance from each other. *L. distinguendus* usually lays one egg per individual host.

The eggs of the ectoparasites are usually slightly stuck to the integument of the host, though some are only placed in the immediate vicinity of the host. In the case of the endoparasites, the eggs are freely floating among the tissues. In *L. distinguendus* the eggs are deposited on the integument of the host.

Among the endoparasitic species, the habit of completing the larval feeding after emergence from the host body has been frequently noted, particularly among the Cheloninae and Macrocentrinae. The larva of *Chelonus blackburni* Cam. emerges from its host when it is only half-grown, then it continues feeding on the host externally. Many species of *Macrocentrus* have the external feeding phase, and emergence from the host body coincides with the third moult of the parasite. In *L. distinguendus* this shift has never been observed.

The reproductive capacity of the species that develop internally in the host, is relatively high while the ectoparasitic species usually have a lower reproductive capacity. The reproductive capacity of *L. distinguendus* is relatively low as reported by the author (1954 a); in three different experiments carried on at 24°C. and 45% R.H., the mean fecundity was 45.5, 60.5 and 164 eggs, respectively.

Among the species that develop externally on a host contained in a cell of any sort, usually the first-stage larva freely moves about over the host body for a certain period. The newly hatched larva of *L. distinguendus* is very active, it moves about for 2-3 hours and sometimes longer before maintaining a fixed connection with the host.

The most extensive feeding by an external parasite larva usually takes place in the last larval stage, in which the suctorial feeding action is replaced by direct feeding upon the body tissues. This is the habit of *L. distinguendus*.

Hosts that are attacked by internal parasites react in several ways which refer to the presence of the parasite within the body. Such hosts are often of a smaller size than healthy larvae of the same age, and toward the end of their life they show an appreciable difference in their colour. Another effect of endoparasitism is the prolongation of the larval period of the host. The healthy larvae of *Coleophora laricella* Hbn., usually spin their cocoons in May while those larvae which are parasitised by *Angitia nana* Grav. remain in the larval stage later than this time before death occurs. In the case of the hosts which are attacked by *L. distinguendus* and which are studied up till now, the above mentioned features do not exist.

From the above discussion, the author is forced to conclude that *Lariophagus distinguendus* Först., contrary to the opinion of HÜSING (1935), is an ideal ectoparasite and even the potentiality of having an internal parasitic phase in the larval stage is excluded.

C. — It seems certain that *L. distinguendus* Först. selects its host on intrinsic features since it is restricted to members of the two orders Coleoptera and Hymenoptera. Of the intrinsic features of these hosts, odour is probably the most important. There are many parasites which are attracted by a certain odour such as the proctotrypi *Polgnotus* which selects cecidomyid larvae and the braconid *Dachnusa* which

parasitises dipterous larvae of the family Agromyzidae (IMMS, 1937). However, one must be cautious before concluding that only intrinsic factors are important. THOMPSON (1934) investigated the host relations of Tachinids which parasitise woodlice of the family Oniscidae and found that the host selection depends on the habitat of the host species. Those species which live in great numbers under the bark of trees were most readily attacked, while those species living in other types of habitats were parasitised to a smaller extent. The evidence for regarding extrinsic factors as being more important in this case is strong but not entirely conclusive. In the selection of the host itself intrinsic factors must be involved while movement and shape help in distinguishing between larvae and pupae

D. — The behaviour pattern outlined above is shown in Figure 12 as a series of responses to specific stimuli. A study of the searching behaviour under field conditions would be of particular interest. *L. distinguendus* is often found in grains' stores where it parasitises the prepupae of *Calandra*, *Stegobium*, *Rhizopertha* and other stored grains' pests. There are a number of references to this in the literature (HÜSING, 1935; LEPESME, 1945; KASCHEF, 1955) but there is no information about the ratio of the parasitised individuals of each host or about the range of the distribution of *Lariophagus*, for this would indicate the searching ability of the parasite. *L. distinguendus* females are not good fliers, but, it is highly possible that they are dispersed by the transportation of the grains.

VI. SUMMARY

(1) *Rhizopertha dominica* Fab. has been known as a very serious pest of stored grains and *Lariophagus distinguendus* Först. can be easily reared in the laboratory.

The duration of the life-history, the number of the larval instars and a brief account of the general biology of *R. dominica* at 26°C. and 70% R.H. has been given. The average duration of the different instars of *Rhizopertha* was as follows: egg, 9 days; first larval instar, 17 days; second, 12 days; third, 10 days; fourth, 10 days; fifth, 8 days; prepupa, 1.5 days; pupa, 7.5 days; total, 75 days. The adults of *R. dominica* usually remains inside the grains for a few days during which their cuticle hardens before eating their way out.

(2) *Lariophagus distinguendus* Först. could be reared as an ectoparasite, on four genera belonging to four different families of the order Coleoptera: (a) *Calandra granaria* L. and *C. oryzae* L. (Curculionidae) (HASE, 1919); (b) *Stegobium paniceum* L. (Anobiidae) (KASCHEF, 1955); (c) *Ptinus tectus* Boield. (Ptinidae) (KASCHEF, 1955), and (d) three samples of *Rhizopertha dominica* Fab. (Bostrychidae) obtained from three different countries (France, Germany and Egypt).

(3) The fecundity of *L. distinguendus* is proportional to the amount of the favourable host stage at its disposition.

(4) The influence of the size and shape of the host puparium as well as the effect of the moisture content of the puparium and its washing with some chemicals on host selection, was investigated.

(5) The improbability of *Lariophagus distinguendus* Först. to be an endoparasite is discussed.

(6) The main factor in the recognition of the host is intrinsic; it is probably chemical.

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CONTROL OF ONION THRIPS BY SURFACE AND SYSTEMIC INSECTICIDES

(with 1 Text-Figure and 4 Tables)

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INTRODUCTION

Onion thrips is everywhere on almost all economic and ornamental plants. Plant hosts given by GHABN (1948) do not exhaust the list. It was reported on carrots in British Columbia, on pyrethrum in Tanganyka and Nyasaland, on crucifers in Japan, and on *Parthenum argentatum*, a rubber shrub, etc. Naturally, the control of such a world-wide pest received much attention. So, many of the known insecticides were tried against it, i.e. naphthalene which was used in nursery beds and on onion plants.

Spray baits containing sugar and tartar emetic or sodium antimonyl hydroxyacetate and sodium antimonyl lactophenolate were, for sometime, important in its control. In greenhouses, satisfactory control was obtained by fumigation with hydrocyanic acid or, nicotine; aerosols containing lorol thiocyanate and methyl bromide or DDT cyclohexanone, lubricating oil, acetone and Freon were also used. Spraying and dusting with nicotine sulphate Dinitro-orthocyclohexyl phenol, chlorinated hydrocarbone as DDT or BHC, organic phosphorous or cyclodiene insecticides were common one after another in Thrips control.

Several new insecticides of the cyclodiene, organic phosphorous and chlorinated hydrocarbons groups appeared in local market. Some work was done in this paper for sorting out insecticides according to their residual effect and initial toxicities to *Thrips tabaci* on cotton and onion.

Experiments were carried out in Alexandria, in 1956, with the emulsion concentrates of the following insecticides applied as sprays.

Aldrin 60%; BHC 20%; DDT 25%; Dieldrin 20%; Endrin 1905%; Fosferno 25%; HO 2671 20% (Hexachlorendomethylene bicycloheptan bis (oxymethylene) sulphite; Metasystox; Toxaphene 50%.

Insecticides 1, 3, 4, 5 and 9 were provided by the SHELL Chemicals and 2 and 6 are ICI products. HO 2671 and Metasystox were supplied by THABETT Brothers.

In 1959, Thimet (O,O,diethyl S-(ethylthiomethyl) phosphorodithioate was provided through HOMSY Brothers and was used for seed treatment. Formulation used was Thimet 44-D, a carbon powder containing 44% actual Thimet and 2% methyl cellulose. That formulation was made of technical material which proved to be 88% pure.

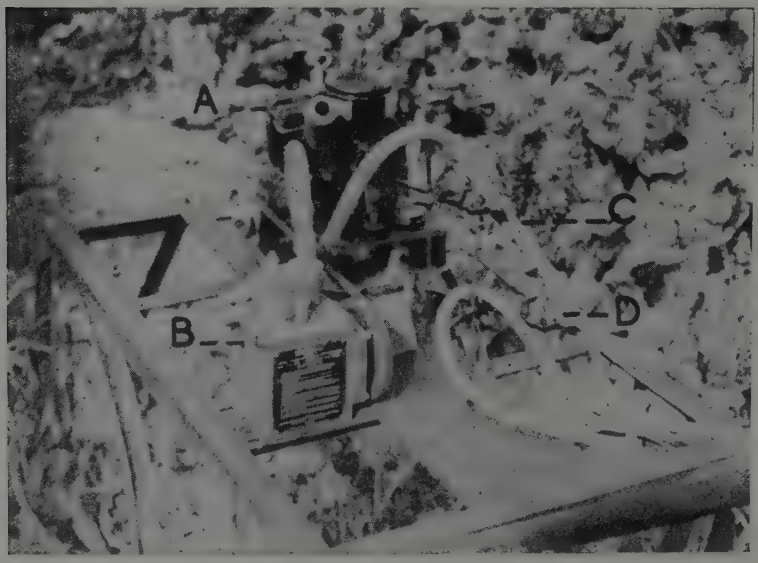

FIG. 1: A set up for collecting *Thrip tabacci* (A, 1/4 HP. motor; B, vacuum pump; C, moisture and dust trap; D, aspirator).

In the following small plot experiment, plots 50 square metres in size were arranged at random, with four replications of each treatment. Emulsion sprays were applied with a cart-type motor pump; a hollow cone nozzle was used to atomize the spray. The output of the pump was fixed at 4.25 litres per minute when spraying the different plots, and the total volume of spray applied was 100 gallons per feddan.

The same concentration 0.1 % of active ingredient in each of above insecticides (1) was used on cotton and on seed onions in each treatment.

The initial applications were made when number of thrips averaged about 25 per plant in onion and about 6 per seedling hole in cotton. In the course of this experiment, three sprays were needed at fifteen days intervals.

In seed treatment experiments, cotton seeds were thoroughly mixed with Thimet dust 24 hours before seeding at the rate of one kilo per 60 kilos of cotton seeds (that equals approximately 7 grams of the active ingredient per kilo cotton seed). Other treatments included dipping seeds in 0.7, 0.35, and 0.1 % Thimet solutions, and 0.05 % Fosferno solution. One kilo of cotton seeds was dipped in one litre of each of the above concentrations for 24 hours. Treated seeds were planted as usual in 50 square metres plots and each treatment had 8 plots.

The population of *Thrips tabaci* was determined by tapping 10 plants picked up at random in each plot across a white cardboard sheet and counting the dislodged insects. Then records were made 3, 6, 12, and 15 days after each insecticide application and in the case of Thimet treatments counts were made 11, 23, and 32 days after seeding.

This technique of Thrips counting was seriously criticized by GHABN (1950) as inadequate and inconvenient.

A vacuum pump driven by $^1/_2$ HP. gasolene motor was mounted on a four wheels, hard driven cart (Figure 1), to suck the Thrips on the plant into small vials which could have been counted later in the laboratory. Results were promising but another pump with higher capacity would achieve thrips counting faster.

RESULTS

Results of treatments on onion (Table I) bears more weight than those on cotton (Table II), because the numbers of thrips on onion were much higher. The superiority of some of the insecticides, however, was established on cotton as well as on onion plants.

Records made three days after treatment on cotton showed that many insecticides gave almost complete initial kill on cotton but not on onion plants. That may be ascribed to the great difference in the size of thrips populations on cotton and onions. Thrips can also take shelter from the insecticide in the fleshy bases of onion leaves while they were exposed on cotton plants to its action. That, with other reasons as the waxy surface of onion leaves, may be held responsible for such discrepancy in the initial kill.

(1) Sprays of metasystox were made according to Company instruction, 100 cc./100 lit. for preparing 0,1 % solution.

All the tested insecticides gave good initial control but some of them gave significantly better residual control of thrips than the others on both crops. Dieldrin and then HO 2671 held the first and second positions in that respect.

Abul Nasr et al. (1957) found that Dieldrin 15, at dosages ranging from 105 to 210 grams of active ingredient (Dieldrin) per acre, was the most effective and the most stable among tested materials.

Table I

Effectiveness of several organic insecticides against Thrips tabaci *on onion (400 cc. active ingredient per acre).*

Insecticides	Average number of thrips per plant											
	First application 18/4/56				Second application 3/5/56				Third application 18/5/56			
	3	6	12	15	3	6	12	15	3	6	12	15
Aldrin ...	4.3	16.0	18.3	23.4	3.25	6.3	2.7	5.8	3.0	2.8	7.3	8.0
BHC	2.2	7.1	12.9	27.44	0.9	5.4	5.6	9.06	3.4	5.6	7.3	10.0
DDT	5.0	16.1	19.1	23.1	4.1	6.6	9.3	5.5	5.0	6.9	12.4	13.1
Endrin....	1.5	12.4	20.3	21.1	1.3	3.0	2.8	2.2	0.8	1.8	2.9	6.6
Fosferno .	0.5	3.6	15.47	30.1	0.9	2.9	6.5	10.7	0.4	3.0	6.8	15.0
Metasystox	4.0	5.4	19.1	30.5	2.4	8.3	6.1	9.6	3.4	2.0	5.25	10.9
HO 2671	1.6	10.1	14.9	11.38	0.93	5.8	5.0	2.9	0.7	2.45	5.43	5.1
Toxaphene	3.0	14.3	19.1	22.6	1.03	5.6	7.0	8.9	1.2	2.06	5.56	8.9
Dieldrin .	0.6	2.0	8.0	9.1	0.76	1.3	1.24	1.15	0.5	1.1	1.6	3.0
Untreated	25.0	41.0	35.3	33.3	24.8	33.8	16.5	13.4	18.0	10. 9	15.4	14.6

Table II

Number of Thrips tabaci *on cotton seedlings after treatment.*

Insecticide	Average number of insects per cotton hole					
	First application			Second application		
	3	9	15	3	9	15
Aldrin	0	2.4	3.1	0	1.6	4.8
BHC	0	2.0	5.0	0	1.8	4.5
DDT	1	3.2	5.1	0	3.3	6.0
Endrin.....	0	0.5	4.2	0.3	1.7	2.1
Fosferno	0	5.5	7.1	0	4.5	7.2
HO 2671	0	4.1	6.2	0	2.3	2.0
Toxaphene.....	0	2.1	4.6	0.2	3.4	4.8
Dieldrin	0	0.9	1.2	0	1.1	0.9
Metasystox	0	5.2	7.4	0.5	5.1	6.0
Control	5.2	8.1	7.0	6.1	7.4	7.1

Endrin which is an isomer of Dieldrin is a close third to HO 2671. It is immaterial to arrange all the others in descending order and that may be impossible by analyzing the few given data. But, generally speaking, it can be said that insecticides of the cyclodiene group gave better residual control than BHC, DDT or the organic phosphorous insecticides.

Thrips might have acquired resistance to BHC and DDT and that may be the reason for achieving poorer control than the cyclodiene and organic phosphorous insecticides. BEN RICHARDSON (1957) reached the same conclusion in Winter Garden, Texas. He also found that thrips became there resistant to the cyclodiene insecticides.

Sometimes, as in the case of seed onions, an insecticide with a strong residual effect should be evaded before the opening of flowers and their readiness for pollination. It will definitely kill and repel the pollinators and consequently decreases the yield. Table III reflects that very clearly, as plots of seed onions treated with Dieldrin gave smaller yield than the other plots. Endrin, which is an isomer of Dieldrin, gave better yields because it is known to be less stable than Dieldrin.

TABLE III

Weight of onion seeds produced by treated seed onions.

Insecticide	Weight of seeds in kgs.	Insecticide	Weight of seeds in kgs.
Aldrin	11.70	Fosferno	11.36
BHC	13.47	Metasystox	12.42
DDT	12.73	HO 2671.....	13.96
Endrin.....	12.32	Toxaphene	13.83
Dieldrin	10.67	Control	11.85

TABLE IV

Control of Onion thrips by soaking or mixing cotton seeds in Thimet solutions or dusts.

Treatment	Average number of thrips per 80 cotton holes		
	11 days	23 days	32 days
Thimet Dust	0	11	68
Soaking in Thimet solutions:			
0.70%	0	7	48
0.35%	0	10	78
0.10%	3	17	120
Soaking in Fosferno solution:			
0.05%	2	190	638
Control	3	336	890

It is therefore recommended to avoid Dieldrin on seed onions at the time of flowering. Endrin, HO 2671, or any other insecticide may be better substitutes.

However, results in Table III show that thrips control increased the seed crop by 18 in the case of HO 2671. No effort was made to estimate the increase in cotton crop due to thrips control. However, KAUFFMAN (1953) proved that early control of thrips on cotton increases its yield.

Systemic insecticides were used against onion thrip on seed onion plants by REYNOLDS (1953). But both Schradan and Systox were inferior to surface insecticides as DDT and Toxaphene. However, it was worthwhile to verify the efficiency of Thimet in seedling protection against *Thrips tabaci* and, as Table IV shows, results are in its favour.

The results show that *Thrips tabaci* was not found in appreciable numbers eleven days after cultivation (29th of March). It appeared in larger numbers afterwards on the 23rd and 32nd day after seeding. However, these numbers were not considered dangerous to the cotton plants, especially as cotton was not yet thinned.

Thimet, in all concentrations, proved to be more effective than Fosferno concentration 0.05%. It was impossible to soak seeds in 0.1% Parathion (active ingredient in Fosferno) because it affects germination at this concentration (SHAZLI and BESHR, under publication).

Dipping for 24 hours in 0.7% seems to give better results than mixing with dust at the same concentration for the same period.

Treated plants looked healthier and stronger than the untreated ones. That complies with the fact that organic phosphorous compounds, to which Thimet and Fosferno pertain, stimulate plant growth and increases plastids in their leaves (HACKSKAYLO, 1955). Absence of thrips and aphids is a factor that contributes to the better condition of plants.

Seed treatment is considered practical as it saves us the trouble of surface spraying. But it is doubted that it is enough for the whole thrips season which extends through May. Unfortunately, that experiment was not continued till the end of May. It was stopped as soon as considerable numbers of thrips (5 per cotton hole) were found in several of the treated cotton holes. That was an indication that Thimet toxicity in plants started to recede. It was a matter, in the authors' opinion, of cleanliness of the field that limited the number of thrips on treated plants rather than their toxicities. That makes it clear that thrips can survive on these plants should they were near to a heavy populations of thrips. It was also noticed that larvae of Aphid-lion became plentiful especially on control plots. The distribution of these predators in the nearly treated plots, decreased the thrips infestation.

So, it is much doubted that seed treatment will import toxicity to the plants through all the season of thrips. Besides, surface spraying repels and kills biting insects that appears early on cotton concurrently with the thrips.

SUMMARY

(1) All tested insecticides were efficient in lowering thrips population on the third day after spraying.

(2) Dieldrin and HO 2671 (400 cc. of active ingredient per acre) kept thrips under control for longer periods than did the other insecticides at the same concentration.

(3) On seed onions Dieldrin reduced the seed yield. Its long residual action was responsible for repelling and killing pollinators.

(4) Thimet seems to protect seedlings for nearly a month but it is doubted that its efficiency lasts over the whole thrips season.

(5) Soaking cotton seeds in Thimet solutions seems to give better results than mixing them with Thimet dust.

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LIFE-HISTORY AND MORPHOLOGY OF *CROCIDOSEMA PLEBEIANA* Z., IN EGYPT

[*Lepidoptera : Tortricidae*]

(with 2 Text-Figures and 1 Table)

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INTRODUCTION

Crocidosema plebeiana came to our attention as the pink bollworm (*Platyedra gossypiella*) was being collected from the hollyhock (*Althaea rosae*). Flowers and seed capsules of the hollyhock were heavily infested with this insect which was mistaken for the pink bollworm when it was sighted for the first time.

WILLCOCKS (1916) stated that the moth of *C. plebeiana* does not attack cotton but might be confused with *P. gossypiella*. Then, it was reported that this insect feeds normally on hollyhock but a single adult specimen has been bred from a larva which was tunneling in the terminal part of the stem of a cotton plant received from Mr. SALVAGO in Behera District (WILLCOCKS, 1922 a). He proceeded "So far as I know, it is unusual for *C. plebeiana* to attack cotton; on one other occasion only has it been noted in connection with cotton, an egg being found on a green boll at Ghezira in 1915". WILLCOCKS (1922 b) mentioned the fact that the larvae feed inside and destroy the young flower buds and attack seed capsules. Full grown caterpillars are about 12 mm. long, greenish in colour with a brown head.

EL-ZOHEIRY and ASEM (1953) collected this insect two times from Egyptian cotton grown in Delta, and it was plentiful on hollyhock, *Abutilon avicennae*, and *Chenopodium*. Infested chinese jute produced galls from terminal leaves in which larvae of *C. plebeiana* and sometimes *Earias insulana* lived. From June to September, *C. plebeiana* had three generations. They also reported that *C. plebeiana* appears on hollyhock earlier than June.

This insect is a European species and might have been introduced from there. ARNOLD SPULER (1910) pictured the moth in his book "European Moths."

STAUDINGER and REBEL (1901), in their "Catalog der Palaearctischen Lepidopteren", recorded its synonyms (*C. plebeiana* Z., 1847; *C. altheana* Mn., 1855; *C. lavaterana* Mill.; *C peregrinana* Möschl, 1866) and distribution (East Germany, South Austria, Andalusia, South France, Corsica, Sicily, Dalmatia, Syria, Australasia, Central and South America).

From the U.S.A., HEINRICH (1921) referred to *C. plebeiana* and to other larvae belonging to thirty-eight species which were confused with the pink bollworm. Hosts of *C. plebeiana* were *Malvastrum specatum*, *Althae rosea*, *Malvaviscus militaris*, and *Hibiscus rosa sinensis*. However, HEINRICH had erroneously recorded it under the family Olethreutidae (known also as Eucosomidae or Epiblemidae).

It is not confined in the palaearctic region by any means. Its occurrence in Samoa, Tonga, and Fiji (HOPKINS, 1928), and on hollyhock in Ceylon (FLETCHER, 1923) was established.

Few reports about its economic importance and the damage it caused to cotton crop in Australia and Italy were given. RUSSO (1947) reported that larvae of *C. plebeiana* mined in the shoots of cotton and attacked the young bolls in Italy. *Crocidosema* (*Wucosoma*) *plebeiana* Z., was officially declared to be a pest in New South Wales, Australia, in 1924. BALLARD (1925) held *C. plebeiana* responsible with other pests for lowering the grade of cotton in Queensland. It punctures the bolls and allows *Fusarium moniliforme* and bacteria to stain cotton and so lowering its grade. GURNEY (1925) described the damage incurred by the cotton tip moth, *C.* (*Eucosoma*) *plebeiana*. It has been recorded as feeding and boring into the terminals and laterals of cotton seedlings. The small larvae thus destroy many leaf buds and crowns of stems and bore for short distances into the pedicles of leaves causing shrivelling of leaf buds and terminals. In 1941-1942, the tip worm attacked seedlings and destroyed a considerable number of terminals in early planted cotton in the Callide Valley in Queensland where it had not previously attracted attention.

Natural enemies of the tip moth were also mentioned from different countries. *Actia eucosmae* was bred from *C. plebeiana* in Queensland (BEZZI, 1926). BEDFORD (1929, 1932) suggested that *Abutilon* is to be grown during the dead season of cotton along the main irrigation canals bordering fields reserved for that crop. That was believed to be due to the fact that *Microbracon kirkpatricki* is very active on *Abutilon* from July for at least four months, a period in which the beginning of infestation of cotton by *Platyedra* occurs.

The above available literature reveals that practically very few work has been done on *C. plebeiana*, especially in Egypt. Therefore, it was thought advisable to deal in the present paper with a study of the more important morphological characters of this insect and of its life history under controlled conditions.

MATERIALS AND METHODS

The moths were kept at room temperature and humidity in empty desiccators covered with perforated steel disks; sugar solution and fresh hollyhock flowers

were daily provided. The eggs with the part of flower on which they were laid were removed to 3 × 5" glass vials which were introduced into desiccators maintained at constant 75% R.H. and 25°C. The larvae and pupae reared were kept in vials plugged with cotton and were enclosed in desiccators kept under the same conditions of humidity and temperature. Humidity was kept constant inside the desiccators by a mixture of glycerine and water.

The hatched larvae were bred on the fleshy bases of petals through which they tunnel, but older larvae were provided with carpels instead. It was possible to sex the larvae when gonads appeared in the males as two conspicuous brown spots on the dorsum of the abdomen; while the females did not show such structures. Sexing was confirmed in the pupal stage, as will be described later, and the opposite sexes were kept apart until moth emergence.

For morphological studies, the desired parts of larvae were treated with 10% KOH, which was afterwards thoroughly removed by rinsing in distilled water. They were then dehydrated by ethyl alcohol, cleared in cedar wood oil, and lastly mounted in Canada balsam. The wings and heads of adults were first bleached and the scales removed in hydrogen peroxide, then the latter was removed by distilled water. They were then treated with 70% alcohol, stained with gentian violet, transferred to 50% alcohol and distilled water, respectively, and finally mounted in glycerine jelly (HAMMAD, 1956).

1. Morphological characters

Moth

The head of the moth (Fig. 1 C) carries two large black compound eyes and two ocelli (oc.) located above the antennal sockets. The antenna (A) is setaceous with fine hairs encircling the antennal segments. The labial palpi (L.P.) are convergent and curved towards the vertex giving the front part of the head a beak-like structure. These palpi are three-segmented with the second segment enlarged and the third pointed. So-called mandibles (M) are lobe-like hairy structure. Fine hairs also cover the tall proboscis (g). The tarsi are five-segmented and end with two fine claws.

The moth (Fig. 1 A) is about 0.6 cm. long and expands about 1.1 cm. The front wing is broad and ends squarely; when at rest, the front wings fold above the body like a roof. The greyish brown back of the moth is crossed by a dark brown pointed triangle proceeded by another triangle with a blunt summit. The latter looks to the naked eye as a trapeze rather than a triangle. Two other triangles are located on the tilted parts of the wings which cover both sides of the body.

The fringe of tall hairs on the hind wing arises from the upper side of the wing and not from the basal part of the Cu (Fig. 1 B). This proves that *C. plebeiana* is a Tortricid and not an Olethreutid as HEINRICH (1921) had classified it. In the fore wing the distal part of the first anal vein (1st A) is preserved and Cu 2 arises

before the fourth of the discal cell. This confirms its classification as a Tortricid (COMSTOCK, 1948).

Egg

The eggs are oval in shape, 0.57 and 0.31 mm. in length and breadth, respectively. When first laid, the eggs are shiny white in colour, but after twenty-four hours their upper surface becomes marked with pink spots which approximately form a circle (Fig. 1 D).

Larva

The larva in its last instar (Fig. 2 A) is about 10-11 mm. long and turns pink in colour in its last few days. However, some larvae stayed greenish in colour till pupation. None of the few larvae which were reared on unripe cotton seeds turned pink. The head capsule and thoracic shield are dark brown. It has three thoracic and ten abdominal segments. There are three thoracic legs, and five pairs of abdominal prolegs which are present on segments 3-6 and 10. The crochets are arranged in a complete circle around the planta of each proleg except the last one where the crochets form half a circle. In contrast with this, the crochets in *P. gossypiella* are arranged in all the prolegs in a semi-circle.

After the third ecdysis, traces of the gonads appear through the transparent body wall of males and become strikingly evident after the fourth. A pair of spiracles is situated laterally on each of the first eight abdominal and the first thoracic segments.

The setae are arranged on the back and sides of the larvae in ten longitudinal lines except in the first thoracic and the last two abdominal segments. Each proleg carries anteriorly three setae (Fig. 2 A).

The head capsule of the mature larva is oval in shape with the mouth parts directed forward, so it is of the prognathous type. Two branching sutures, the frontal (fs) and epistomal (eps), conspicuously snake on the dorsal surface of the head (Fig. 2 C). The frons (Fr) looks like an inverted Y with the dorsal part (stem of Y) invaginated into the head capsule. The ventral part (arms of Y) is covered by the clypeus (c), and extend under the parts known as the adfrontals (ad). The vertex does not exist due to the emargination of the dorsal wall of the cranium. Each mandible is 5-toothed, a character which distinguishes *C. plebeiana* from *P. gossypiella*. Ventrally (Fig. 2 B), the head shows the maxillae, labium and hypopharynx united in a labio-maxillary hypopharyngeal complex.

Three lobes are distinct in that under lip complex. The two lateral lobes are the maxillae and the median lobe is the labium with the hypopharynx adnate on its anterior surface. Each maxilla consists of a small sclerotic triangular cardo (Cd) and a large membranous stipes (Mx. st.) which carries distally a two-segmented maxillary palp (mx. P.) which ends by four spines (Fig. 2 G). Internally to the palp, the stipes bears also a maxillary lobe (mx. 1.) which is carried on a palpifer and consists of a basal segment carrying on its apex two small segmented cylinders and two

setae. The cardo articulates with that part of the head known as the hypostoma (Hst) which posteriorly limits the under lip complex (Fig. 2 B).

The stipital ridge (st. r.) extends mesally to the maxillary stipes. The median lobe of the under lip complex contains distally a sclerite, the prementum (pmt), and bears anteriorly the spinneret (sr.), and two papillary labial palpi (lb. p; Fig. 2 B and H). It is known in Lepidoptera that the hypopharynx and prementum form together a united hypopharyngeal-premental lobe through which the silk duct (press) passes. Each antenna (Fig. 2 D) is four-segmented, the second segment being the largest. Apparently, the antenna bears basiconic and styloconic sensillae on the apex of the second and third segments. The distal segment is very delicate and ends in a styloconic sensilla. There are six ocelli (oc.) (Fig. 2 B) on each side of the head under the antenna. Two of these only partially appear in the dorsal view of the head capsule. The ocelli are arranged in three rows forming letter n.

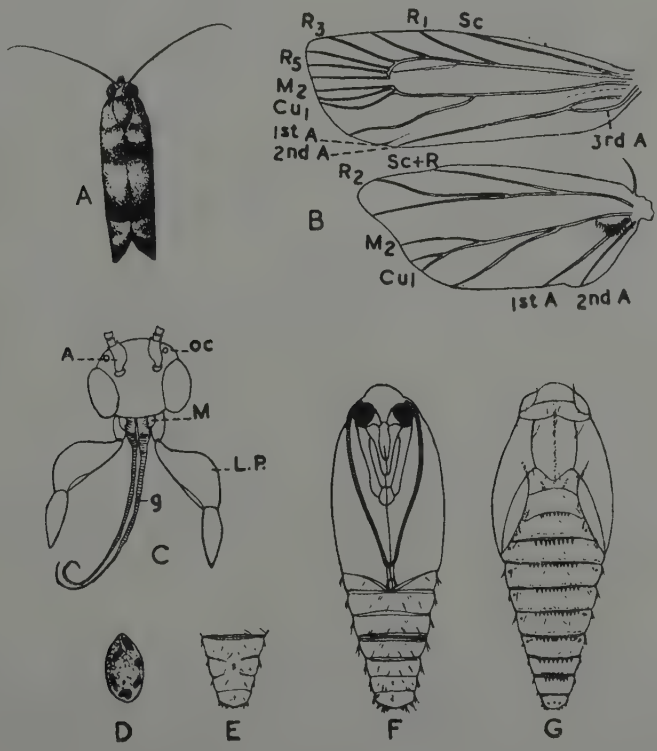

FIG. 1: A, moth of *Crocidosema plebeiana* Z.; B, wing venation; C, head and its appendages; D, egg; F, abdominal tip of female pupa; F, male pupa (ventral view); G, male pupa (dorsal view).

P u p a

The yellowish brown pupa (Fig. 1 F, G) is 6 mm. long and its body is clearly divided into head, thorax and abdomen. It shows dorsally three thoracic and ten abdominal segments, while from the ventral side only six abdominal segments are completely apparent. The wings and thoracic appendages are the most important features of the ventral view and hides three abdominal segments and part of the fourth.

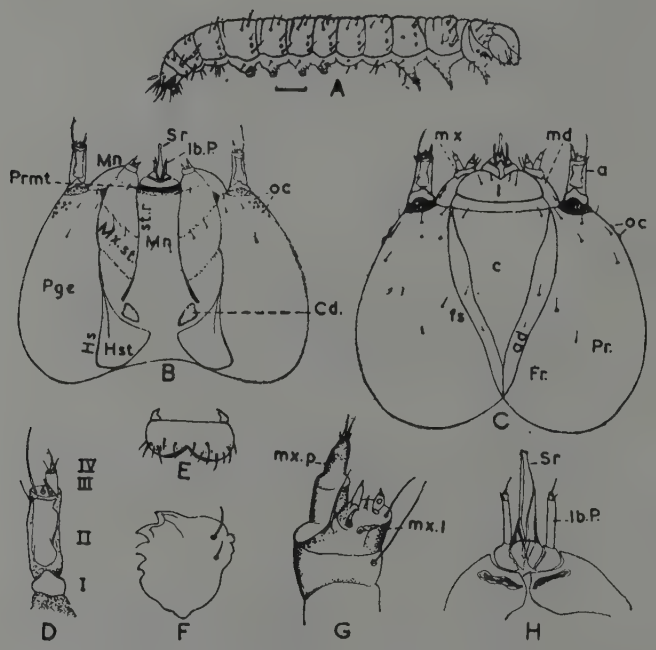

FIG. 2: A, fully mature larva of *Crocidosema plebeiana* Z.; B, ventral view of head capsule of larva in its last instar; C, dorsal view of head capsule; D, antenna of larva; E, F, G and H, mouth parts of larva (labrum, mandible, maxillary palp and maxillary lobe, labial palpi and spinneret, respectively).

A conspicuous feature of the pupa is the presence of a series of short, stout spines on the abdominal segments; these series of spines are known as combs or ctenidia. Each abdominal segment bears dorsally a row of stout ctenidia (Fig. 1 G). Below this row is another row of fine short bristles on each abdominal segment, except the last three. Segments 7, 8, 9 and 10 are devoid of spiracles, while the first six abdominals have a pair each.

Sexing the pupae was based on the distance between the anal and the genital apertures. In the male the two apertures closely follow each other in the two last abdominal segments (Fig. 1 F), while in female they are one segment apart (Fig. 1 E).

2. Life-history

The eggs were laid during the night on the calyx and epicalyx, but never on the petals, of the hollyhock flowers. Removal of the eggs from the spiny surface of these parts of the hollyhock flower was difficult due to the tenderness of the eggs. It seems that the eggs were probably wedged among the spines present on the oviposition sites, and that no glue was needed for fixing them on the surface. Although the eggs were usually laid singly, they were sometimes observed to be laid in one-layered, irregularly-shaped, small batches.

Data on incubation period of eggs of *C. plebeiana* were obtained by keeping 366 eggs at constant 25°C. and 75% R.H. The percentage of eggs that hatched after 2, 3 or 4 days proved to be 16.1, 58.2 and 9.2%, respectively. The average incubation period was 2.9 ± 1.03 days. 16.5% of the eggs failed to hatch.

Larvae were abundant in flowers and seed capsules of the hollyhock from May to August. Infested flowers had black moldy and sticky holes on the calyx and epicalyx. Newly hatched larvae bore through these parts of the flower and the fleshy bases of the petals. Larvae in their first instars tunnel through the bases of petals; when they get older they live in carpels. All trials to breed young larvae on calyx and epicalyx failed. Four female and six male larvae were used to determine the number and duration of the instars. Larvae moulted five times, and the last moult took place shortly before pupation. The average periods of the five instars were 3±0, 3.7±0.38, 2.6±0.5, 2.6±0.71 and 5.7±0.67 days, respectively. The fully mature larvae never pupated inside the carpels but spun white cocoons on the cotton

TABLE I

Duration of life-cycle of Crocidosema plebeiana *at 25°C. and 75% R.H.*

Stages and Instars	Duration of stages and instars in days									Average duration in days
	2	3	4	5	6	7	8	9	10	
Egg	59	213	34	—	—	—	—	—	—	2.9 ± 1.03
Larva:										
1st instar	0	10	0	—	—	—	—	—	—	3.0 ± 0.0
2nd instar	1	1	8	—	—	—	—	—	—	3.7 ± 0.38
3rd instar	3	6	—	—	—	—	—	—	—	2.6 ± 0.50
4th instar	4	4	1	—	—	—	—	—	—	2.6 ± 0.71
5th instar	—	—	—	3	5	1	—	—	—	5.7 ± 0.67
Pupa	—	—	—	—	1	5	7	3	2	7.8 ± 1.05

stoppers or on the bottom of the vails in which they were bred. Pupae were found on hollyhock plants between calyx and epicalyx or on petals near exit holes or on crumbled petals and plant leaves. The pupal period of eighteen pupae averaged 7.8 ± 1.05 days. Observations on four pairs of moths kept in 4.7 lit. desiccators and under room conditions averaging 27.5° C. and 75% R.H. revealed the following facts: average longevity of moths 9.7 days; number of eggs laid per pair 70-103; and pre-oviposition period 3-5 days.

The data on the duration of all stages of the insect are given in Table I.

SUMMARY

Important morphological characters of the larva, pupa and adult of *Crocidosema plebeiana* and its life-history under 25°C. and 75% R.H. were studied.

Larvae and pupae of *C. plebeiana* are distinguished from those of *Platyedra gossypiella* by the following characters: (1) Larvae are smaller and usually turn pink in colour at their last few days. The crochets are arranged in a complete circle around the planta of each proleg, where as the crochets in *P. gossypiella* are arranged in a semi-circle; (2) each mandible is 5-toothed; in pink bollworm it is 4-toothed; (3) each first seven abdominal segments of *C. plebeiana* pupa, bear two rows of spines and bristles; (4) *C. plebeiana* was found possible to be reared on cotton bolls or immature cotton seeds; (5) duration of its life-cycle was 28.3 days, egg-stage 2.9 days, larval stage 17.6 and pupa stage 7.8 days. Longevity of adult was 9.7 days and number of eggs was 70-103 per pair of moths.

ACKNOWLEDGMENT

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THE MOUTH PARTS OF THE LARVAL INSTARS OF *PSOROPHORA HOWARDI* (COQUILLETT)

[*Diptera : Culicidae*]

(with 39 Text-Figures)

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CONTENTS

I. Introduction. —II. General morphology of the head. — III. The mouth parts of the fourth instar larva. — IV. The mouth parts of the third instar larva. —V. The mouth parts of the second instar larva. — VI. The mouth parts of the first instar larva. — VII. Summary of the important instar differences. —VIII. Key to the larval instars of *Psorophora howardi* based on the head structures. — IX. Acknowledgments. — X. Selected references.

I. INTRODUCTION

In a previous paper, the author (1957c) studied the morphology of the mouth parts of the larval instars of *Psorophora ciliata* (Fab.). Similar to *P. ciliata*, the larva of *P. howardi* is predacious during the fourth, third and second instars; while the first instar feeds by filtering the food particles found in the medium. Ross (1947) stated that the larva of *P. ciliata* is identical to that of *P. howardi*, and that the only reliable difference found to date is the single or split condition of the lateral hair of the anal segment in *P. howardi*, while being branched in *ciliata*. Other pronounced differences, however, are indicated by the author in the mouth parts of these two species.

The homology of the mouth parts with those of the generalized insects have been discussed in the study of the mouth parts of the larval instars of *Anopheles quadrimaculatus* (Say) and *Aedes aegypti* Linn. (SHALABY, 1956 and 1957a). A detailed study of the homology of the labium-hypopharynx complex of the fourth stage larva of *Culex molestus* Forsk. has been accomplished (SHALABY, 1957).

II. GENERAL MORPHOLOGY OF THE HEAD

The head capsule of the fourth stage larva of *P. howardi* is more or less quadrate in shape. It is about 1.372 mm. in width, and highly sclerotized and pigmented. The frons (Fig. 2, F) covers almost the entire dorsum of the head. It is bounded laterad by the frontal sutures, and cephalad by the fronto-clypeal suture (FCS). The clypeus is divided by the clypeal suture (CS) into the pre-clypeus and the post-clypeus (Prc and Poc). The antennae (Fig. 1, A) are short and slender. Each antenna has one hair and two short papilliform processes at its distal end which are of a sensory function.

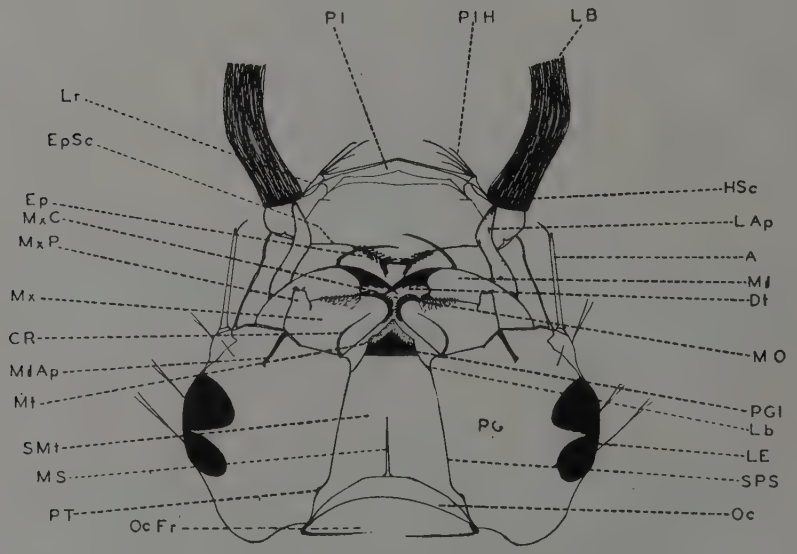


FIG. 1: Ventral aspect of the head of the fourth instar larva.

The larval eyes (Fig. 1, LE) are located on the ocular lobes, laterad of the post genae (PG). Each eye is heavily pigmented and deeply emarginate mesad. It is important to notice that the glossa of the labium is apparently absent similar to that of *P. ciliata* (SHALABY, 1957c). It has been noticed that the two posterior tentorial pits (PT) are located near the proximal extremities of the submental-postgenal sutures (SPS). The maxillae and the mandibles (Mx and Md) are located laterad of the mouth opening (MO) and are adapted for the predacious method of feeding.

III. THE MOUTH PARTS OF THE FOURTH INSTAR LARVA

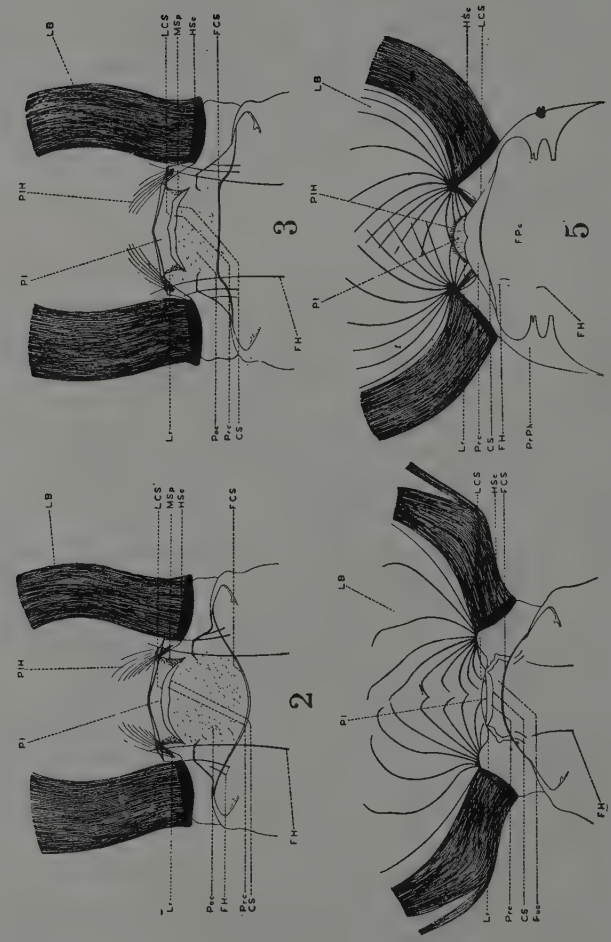
The labrum

The labrum (Fig. 2, Lr) is located at the cephalic end of the head. It is separated from the clypeus by the labro-clypeal suture (LCS). The clypeal suture is short and slender, with its lateral ends directed latero-caudad to fuse with those of the labro-clypeal suture. The post-clypeus is bounded caudad by the fronto-clypeal suture (FCS) which is prominently curved. There are three pairs of frontal hairs (FH) which arise from the cephalic region of the frons and extend cephalad. The most mesal pair is the longest, most pigmented and extends cephalad a short distance beyond the palatum (Pl). The other two pairs arise from the cephalo-lateral regions of the frons. They are shorter, more slender and less pigmented than the mesal pair.

The palatum (Figs. 2 and 7, Pl) is more or less quadrangular in shape. It is slightly sclerotized and pigmented with a heavily pigmented cephalic margin. The cephalic margin of the palatum is convex mesad. There are two quadrangular shaped sclerites which connect the mesal ends of the hair-bearing sclerites (HSc) with the lateral ends of the cephalic margin of the palatum. These two quadrangular shaped sclerites bear the palatal hairs (PlH) along their mesal margins, with eight hairs on each side. The palatal hairs are fine and extend meso-cephalad. There are numerous micro-spines (MSp) which arise from the lateral regions of the ectal surface of the palatum.

The labral brushes (Figs. 2 and 7, LB) are located laterad of the palatum. The hairs of the labral brushes (Fig. 2, HLB) are strong, elongate, slightly curved and serrated. They are wonderfully adapted for the predacious method of feeding. These hairs arise from the hair-bearing sclerites which are heavily pigmented. The mesal hairs of the labral brushes (Fig. 36, HLB, m) are serrated along the entire margin. The lateral hairs (HLB, l), however, are serrated along the distal two-thirds of their mesal margin. These serrations are triangular in shape, and sharply pointed. They are longer and stouter cephalad and shorter and slender caudad. The serrations of the mesal hairs are large, while those of the lateral hairs are relatively small. Each labral brush is composed of one group of hairs, which consist of more than one series of hairs.

The labral brushes are strengthened and supported by two labral apodemes (Fig. 7, LAp) on the ental surface of the labrum. Each labral apodeme is elongated, sclerotized and pigmented. The cephalic end of the labral apodeme is somewhat rounded, while the proximal end is pointed. The mesal margin of the apodeme is convex, while its lateral margin is concave. The proximal third of the labral apodeme is less pigmented and narrowed to a sharp point at its proximal end. Each labral apodeme possesses three processes. The anterior process of the labral apodeme (AAp) is attached to the lateral margin of the distal third of the labral apodeme.



FIGS. 2-5: Dorsal aspect of the cephalic region of the (2) fourth, (3) third, (4) second, and (5) first instar larval head, respectively.

It is triangular in shape, short, pigmented and extends laterad. The medial process of the labral apodeme (MAp) is attached to the disto-mesal region of the median third of the labral apodeme. It is short, triangular shaped, pigmented, sharply pointed and extends meso-caudad. The posterior process of the labral apodeme (PAp) is attached to the distal end of the proximal third of the apodeme. It is large, stout, highly sclerotized, heavily pigmented and extends meso-caudad. There is a small membranous area attached to the distal end of the mesal margin of the proximal third of the labral apodeme. These membranous areas serve for the attachment of the lateral extremities of the epipharyngeal sclerite (EpSc).

The epipharynx

The epipharynx (Fig. 7, Ep) is located on the ental surface of the labrum. It resembles, to a large extent, that of the larva of *P. ciliata* (SHALABY, 1957c). The epipharynx of *P. howardi* is composed of the epipharyngeal sclerite (EpSc), the epipharyngeal hairs (EpH) and the epipharyngeal processes (EpP). The epipharyngeal sclerite extends transversely between the proximal thirds of the labral apodemes, and is arched caudad at the meson. It is stout mesad and slender laterad. The lateral extremities of the epipharyngeal sclerite are connected with the small membranous areas which are attached to the disto-mesal end of the proximal third of the labral apodeme. The epipharyngeal hairs are relatively long mesad and shorten gradually laterad. Each epipharyngeal hair, under higher magnifications, is relatively short, pigmented, stout and brush-shaped, as it ends distally in numerous, fine and short branches.

The epipharyngeal processes are attached to the mesal region of the caudal margin of the epipharyngeal sclerite. There are about ten or twelve slightly curved processes, with five or six processes on each side of the mesal line. Each epipharyngeal process, as seen under the high magnifications, is hair-like, relatively long, pigmented and provided with a great number of very short and fine projections along the distal two thirds of the mesal margin.

The mandibles

The mandibles (Figs. 11 and 15) are located dorsad of the maxillae. Each mandible is sub-quadrangular in shape, strong, sclerotized and pigmented. It serves as the main grabbing apparatus at the time of catching the prey. The dentes are strong, elongate and attached to the mesal margin. They are divided into a ventral group (Figs. 11 and 15, VDt) and a dorsal group (DDt). The ventral group is composed mainly of two large and strong serrated dentes, a cephalic tooth and a caudal tooth which extend more or less mesad. Near the caudal end of the mesal-margin, there is a heavily pigmented sclerite, which is provided with seven or eight teeth-like projections. The cephalic serrated tooth is stout, elongate and sharply pointed. It is serrated along its caudal margin. The serrations are three in number and are

triangular shaped, sharply pointed and extend mesad. The cephalic part of the base of the cephalic serrated tooth is produced into an elongate and slender spine-like tooth which extends mesad. In *P. ciliata*, this spine-like tooth is absent (SHALABY, 1957c). The caudal serrated tooth is attached to the middle of the mesal margin of the mandible. It is highly sclerotized, heavily pigmented, but shorter than the cephalic serrated tooth. The caudal tooth is serrated along its caudal margin. The serrations are six in number and are small, triangular in shape, sharply pointed and extend meso-caudad. The dorsal group is located at the meso-cephalic region of the mandible. It is composed of two dentes, a large tooth and a small tooth, which lie dorsad of the ventral dentes. The small tooth is on a more ventral plane than the large tooth. The large tooth is highly sclerotized, heavily pigmented and somewhat pointed. The small tooth lies ventrad of the proximal region of the large tooth. Both the two dentes are curved and extend mesad. It must be mentioned, however, that there is a single dorsal dent in *P. ciliata* (SHALABY, 1957c). There are six small teeth (Fig. 15, Th) which arise from the mesal region of the dorsal aspect of the mandible. The mandibular arms (Figs. 11 and 15, MdA) are attached to the meso-cephalic end of the mandible, laterad of the dentes. They are two in number, slightly sclerotized, sharply pointed and extend meso-cephalad.

The meso-caudal margins of the mandible are sclerotized and pigmented along their entire length. The ventral meso-caudal margin is widened into a traingular shaped structure at its disto-mesal end. The dorsal meso-caudal margin is very slightly widened at its disto-mesal end. The tendon (Td) is connected to the triangular shaped distal end of the ventral meso-caudal margin of the mandible. The mandible is articulated to the ventral wall of the head capsule by the preartis and the postartis (PrA and PoA). The articulation is strengthened and supported by the mandibular apodeme (MdAp). This apodeme is heavily sclerotized, pigmented and is attached to the preartis. The latero-cephalic margin of the mandible is convex. It ends distally in a relatively pigmented area from which arises the lateral bristle (LBr). The lateral bristle is rigid, elongate, pigmented and extends meso-cephalad. There is a small tubular projection laterad of the bristle.

The mandibular comb (Fig. 15, MdC) is located at the meso-cephalic region of the dorsal aspect of the mandible. It lies dorsad across the ventral as well as the dorsal dentes, and extends meso-caudad. The comb is composed of about 10 or 11 setae which are slightly curved. The setae are longer cephalad and shorten gradually caudad. They arise on a longitudinal and pigmented short sclerite (ScC). In *Aedes aegypti* there is a mandibular comb in addition to the mandibular brush (SHALABY, 1957a). The author believes that this comb is not homologous to that of *P. howardi*.

The maxillae

The maxillae (Figs. 19 and 20) are located ventrad of the mandibles. They are oval in shape, highly sclerotized, heavily pigmented and resemble, to a great

extent, those of the larva of *P. ciliata* (SHALABY, 1957c). Each maxilla is composed of the galea (Ga), the lacinia (Lc), the cardostipes (CdSt), the maxillary palpus (MxP) and the palpifer (Pf). The meso-caudal margin of the maxilla is more or less straight. It is provided with a few short, rigid setae along its entire length. The setae are longer cephalad and shorten gradually caudad. The chitinous ridge (CR) is relatively slender, sclerotized and heavily pigmented. It runs between the galea and the lacinia and extends caudad, until it reaches the cardostipes where it bends meso-caudad to fuse with the entoparartis at the meso-caudal end of the maxilla. The ridge ends distally a short distance before it reaches the meso-cephalic end of the maxilla.

The maxilla is articulated to the ventral wall of the head capsule by means of the mesal entoparartis and the lateral exoparartis (Enp and Exp). The maxillary palpus (Mxp) is located on the dorsal region of the maxilla. It is short, stout, slightly pigmented and bears the sensoria (S) at its distal end. These sensoria are short, slightly pigmented and four in number. The maxillary palpus is borne on the palpifer (Pf) which is more or less quadrangular in shape and slightly pigmented. It is attached laterad of the cardostipes.

The maxillary combs (MxC) are three in number. They are located on the cephalic end of the maxilla, as in the case of *P. cilata*. Each comb is composed of numerous, relatively short and rigid setae. These setae are heavily pigmented and are directed, more or less, meso-cephalad. The setae of one comb may overlap those of the other combs. There is a slight difference in size between the three combs. There is a short needle-like spine (Fig. 19, Sp) which arises from the cephalic region of the lacinia and extends meso-cephalad.

The labium

The labium (Fig. 1, Lb) is located at the meso-caudal region of the ventral aspect of the head. SHALABY (1957), in his discussion of the homology of the labium-hypopharynx complex of the larva of *Culex molestus* Forsk., stated that the labium consists of the submentum, the mentum and the ligula which consists of the glossa and the paraglossa. The labium of the larva of *P. howardi* is composed of the submentum (SMt), the mentum (Fig. 1 Mt and Fig. 24) and the paraglossa (Fig. 1, PGl and Fig. 28). The glossa is apparently absent as in the case of *P. ciliata*. The cephalic part of the labium, which consists of the mentum and the paraglossa, projects forward in the angle formed between the meso-caudal margins of the maxillae. The submentum is sclerotized, heavily pigmented and quadrangular in shape. The median suture (Fig. 1, MS) runs along the middle of the submentum and extends only a short distance cephalad.

The mentum (Fig. 24) is located cephalad of the submentum and ventrad of the paraglossa. It is roughly pentangular in shape, slightly sclerotized and pigmented. It possesses a lightly pigmented and convex ridge (R) which runs trans-

versely across the middle region of the mentum. In *P. ciliata*, this ridge is absent (SHALABY, 1957c). The meso-cephalic end of the mentum is produced into a few small teeth (Th), which range from six to eight in number.

The paraglossa (Fig. 28) is located dorsad of the mentum and ventrad of the hypopharynx (Fig. 32). It is triangular in shape, highly sclerotized and heavily pigmented. There are some variations in the number of teeth among different specimens. Out of nine specimens, seven specimens had 16 teeth, seven teeth on the left side, eight teeth on the right side, and a disto-central tooth. The two other specimens had 18 teeth, eight teeth on the left side, nine teeth on the right side, and a disto-central tooth. Nevertheless, the paraglossa appears bilaterally symmetrical. It is noticed that the two latero-caudal teeth on each side are greatly enlarged and sharply pointed. There is a heavily pigmented and broad sclerite which is located at the caudal region of the paraglossa.

The hypopharynx

The hypopharynx (Fig. 32) is located dorsad of the paraglossa, forming the floor of the mouth cavity. It is roughly triangular in shape and not bilaterally symmetrical. The cibarial bars (CB) are connected with the latero-cephalic ends of the hypopharynx. The hypopharynx is armed with about 70 hypopharyngeal spines (HypSp) which are triangular in shape, sharply pointed and heavily pigmented. They are arranged in no particular order over the area of the hypopharynx. The transverse cephalic region of the hypopharynx is more pigmented than the rest of the hypopharynx and is provided with the majority of the hypopharyngeal spines. These spines differ from each other in size and shape. The hypopharyngeal processes (HypP) are connected with the latero-cephalic regions of the hypopharynx. These two processes are heavily pigmented, highly sclerotized and large in size. There are one or two pairs of slender and somewhat pointed movable spines (MvSp).

IV. THE MOUTH PARTS OF THE THIRD INSTAR LARVA

The head capsule of the third instar larva is about 0.937 mm. in width. It is less sclerotized and less pigmented than that of the fourth instar.

The labrum

The labrum (Fig. 3, Lr) consists of the disto-median palatum and the lateral labral brushes. The fronto-clypeal suture (FCS) is more or less straight, with its lateral ends bent latero-caudad, while that of the fourth instar is concave. There are three pairs of frontal hairs which are similar to those of the fourth instar.

The palatum (Figs. 3 and 8, Pl) is quadrangular in shape. It is less sclerotized and less pigmented than that of the fourth instar. The palatal hairs (PlH) are fine,

relatively short and extend meso-cephalad. They are 12 in number, with six hairs on each side. The microspines (Fig. 3, MSp) are fewer and lighter coloured than those of the fourth instar.

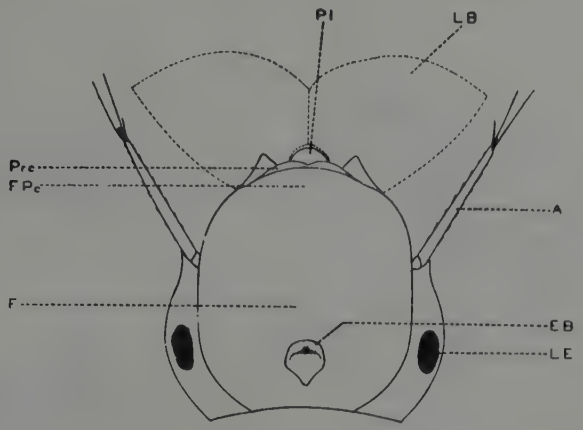


FIG. 6: Dorsal aspect of the first instar larva head showing the egg burster (EB).

The labral brushes (Figs. 3 and 8, LB) are composed of a great number of hairs. They are less dense and lighter coloured than those of the fourth instar. As in the fourth instar, the hairs of the labral brush are serrated, thus being adapted for the predacious feeding habit. The mesal hairs of the labral brush (Fig. 37, HLB, m) are serrated along the distal three quarters of the mesal margin, while the lateral hairs (HLB, l) are serrated along the distal two-thirds of the mesal margin. The serrations here are shorter and lighter coloured than those of the fourth instar.

The apodemes of the labral brushes consist of two elongated labral processes (Fig. 8, LAp) which are less sclerotized and less pigmented than in the fourth instar. The anterior process of the labral apodeme (AAp) is triangular in shape, short and extends laterad. The median process of the labral apodeme (MAp) is attached to the distal end of the mesal region of the medial third of the labral apodeme. It is short, triangular in shape, sharply pointed and extends meso-caudad. The posterior process of the labral apodeme (PAp) is elongate, highly sclerotized, heavily pigmented and extends meso-caudad. There is a small membranous rounded area which is attached to the distal end of the mesal margin of the proximal third of the labral apodeme, similar to that of the fourth instar.

The epipharynx

The epipharynx (Fig. 8, Ep) is composed of the epipharyngeal sclerite (EpSc), the epipharyngeal hairs (EpH) and the epipharyngeal process (EpP). The epi-

pharyngeal sclerite is much similar to that of the fourth instar. It is a little less sclerotized and pigmented. The epipharyngeal hairs are similar in structure to those of the fourth instar, but are slightly fewer and lighter coloured. The epipharyngeal processes are about ten in number, with five processes on each side of the mesal line.

The mandibles

The mandibles (Figs. 12 and 16) resemble, to a large extent, those of the fourth instar. The ventral dentes (VDt) are composed mainly of two serrated dentes, a cephalic serrated tooth and a caudal serrated tooth. There is a sclerotized area near the caudal end of the mesal margin of the mandible which is produced into about six small teeth-like projections. As in the fourth instar, there is an elongated and slender needle-like tooth which arises from the cephalic region of the base of the cephalic tooth. These teeth, in general, are less pigmented than those of the fourth instar. The dorsal dentes (DDt) consist of two dentes, a large tooth and a small tooth, which are smaller and less pigmented than in the fourth instar. The mandibular arms (MdA) are three in number as in the fourth instar, but less sclerotized and less pigmented. The six small teeth (Fig. 16, Th) are small and slightly pigmented.

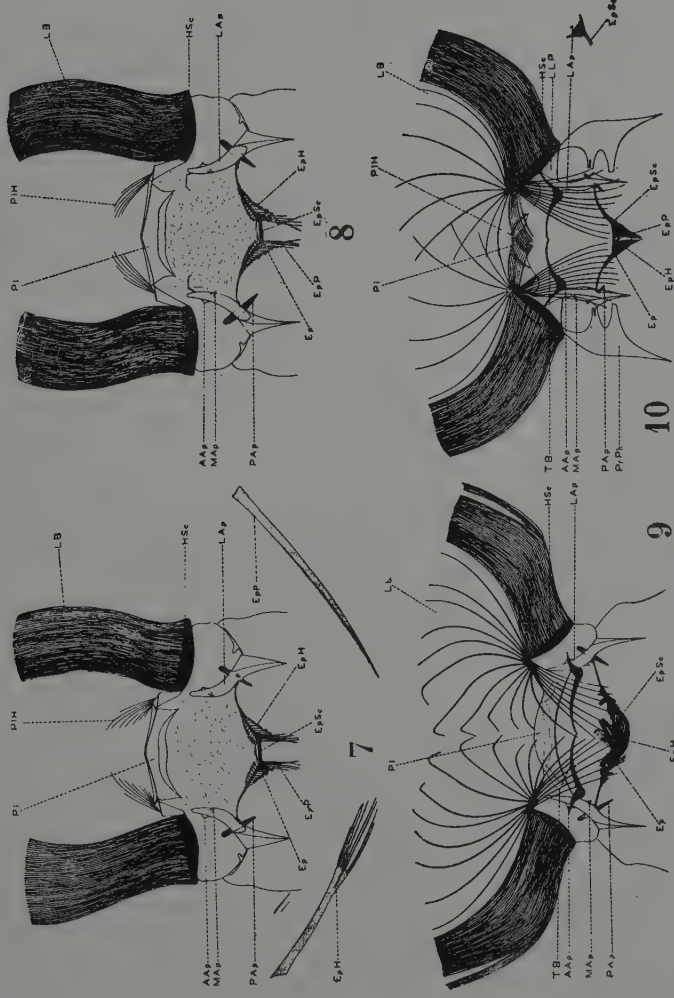
The meso-caudal margins of the mandible are sclerotized and heavily pigmented along their entire length. The meso-cephalic end of the ventral meso-caudal margin is slightly widened. The mandible is articulated to the ventral wall of the head capsule by means of the preartis and the postartis (Figs. 12 and 16, PrA and PoA). The articulation is strengthened by the mandibular apodeme (MdAp) which is comparatively short. The lateral bristle (LBr) is less rigid and less pigmented than that of the fourth instar.

The mandibular comb (Fig. 16, MdC) is composed of ten slightly curved setae as in the fourth instar. The sclerite bearing the comb (ScC) is comparatively slender.

The maxillae

The maxilla (Fig. 21) is composed of the galea (Ga), the lacinia (Lc), the cardostipes (CdSt), the maxillary palpus (MxP) and the palpifer (Pf) as in the fourth instar. The setae on the meso-caudal margin of the maxilla are fewer, shorter and lighter coloured than those of the fourth instar. The chitinous ridge (CR) is comparatively slender and less sclerotized.

The maxilla is articulated to the ventral wall of the head capsule by means of the entoparartis and the exoparartis (Enp and Exp) as in the fourth instar. The maxillary palpus (MxP) is slightly short and lightly coloured, with four sensoria at (S) at its distal end. The palpifer (Pf) is less sclerotized and less pigmented than that of the fourth instar. The microspines (MSp) on the latero-cephalic margin of the maxilla are comparatively few and lightly coloured. The maxillary spine (MxSp) is a little shorter and lighter coloured than that of the fourth instar.



FIGS. 7-10: Ventral aspect of the cephalic region of the (7) fourth, (8) third, (9) second, and (10) first instar larval head, respectively.

The maxillary combs (MxC) are three in number. The setae of the combs are lighter coloured than those of the fourth instar. The spine (Sp) which arises from the cephalic region of the lacinia, is slender and slightly short.

The labium

The labium is composed of the submentum, the mentum and the paraglossa. There is no illustration here for the submentum because of it great similarity to that of the fourth instar.

The mentum (Fig. 25) is less sclerotized, less pigmented and smaller in size than that of the fourth instar. It is roughly triangular in shape. The meso-cephalic end is provided with about six spine-like teeth (Th) which are sharply pointed, but less pigmented than those of the fourth instar. The ridge (R), which runs transversely across the middle of the mentum, is slightly convex, short and lightly coloured.

The paraglossa (Fig. 29) is comparatively small in size. It is composed of 16 teeth, eight teeth on the left side, seven teeth on the right side and a disto-central tooth. Out of seven specimens which have been dissected, six paraglossae consisted of 16 teeth, and one paraglossa consisted of 15 teeth only, with seven teeth on each side of a disto-central tooth.

The hypopharynx

Like that of the fourth instar, the hypopharynx (Fig. 33) is trian gular in shape and not bilaterally symmetrical, though being less sclerotized and less pigmented. The cibarial bars (CB) are connected with the cephalo-lateral ends of the hypopharynx. The hypopharyngeal spines (HypSp) are smaller than those in the fourth instar. The majority of these spines are arranged along the transverse and cephalic area, while the rest of the spines are scattered over the median region of the hypopharynx. The writer has not been able to trace the salivary ducts in this instar. As in the fourth instar, two large hypopharyngeal processes (HypP) are located at the cephalo-lateral ends of the hypopharynx. There are two pairs of movable spines (MvSp) which are more slender and less pigmented than those of the fourth instar.

V. THE MOUTH PARTS OF THE SECOND INSTAR LARVA

The head capsule of the second instar larva of *P. howardi* is about 0.552 mm. in width.

The labrum

The labrum (Fig. 4, Lr) resembles, to some extent, that of the filtering or grazing feeding larvae. It is noticed that the labro-clypeal suture (LCS) does not

extend to the sides of the head as in the advanced instars. Its lateral ends are bent latero-caudad, and then caudad to met the fronto-clypeal suture (FCS). The clypeal suture (CS) is slightly sinuate. Its lateral ends do not fuse with those of the labro-clypeal suture, thus differing from the third and fourth instars. The frontal hairs (FH) are shorter, more slender and lighter coloured than those of the advanced instars.

The palatum (Figs. 4 and 9, Pl) is membranous and semi-oval in shape. The quadrangular shaped sclerites which connect the palatum with the hair-bearing sclerites in the third and fourth instars are here absent. It is noted also, that the palatal hairs are absent. The microspines which arise on the lateral regions of the palatum of the older instars are also absent. The palatum, therefore, presents an important feature that helps differentiation between the second and the third or the fourth instar.

The labral brushes (Figs. 4 and 9, LB) look more like those of the filtering or grazing feeding larvae, than those of the predacious type. Each labral brush consists of numerous hairs which are finer, shorter and lighter coloured than those of the advanced instars. The mesal hairs of the labral brush (Fig. 38, HLB, m) are curved, short and serrated along the distal two-thirds of the mesal margin. The intermediate hairs of the labral brush (i) are longer and finer than the mesal hairs and are serrated along the distal half of the mesal margin. The lateral hairs of the labral brush (l) are long, fine, lightly coloured and serrated only along the distal third of the mesal margin. Each labral brush is made up of three groups of hairs. The lateral and the largest group arises from the entire length of the hair-bearing sclerite (Figs. 4 and 9, HSc). The second and mesal group arises on the distal end of the hair-bearing sclerite. It is composed of a few and short hairs which are curved and extend meso-cephalad. The third group is located on the ental surface of the labrum. The hairs of this group are very slightly curved, relatively long and extend meso-caudad.

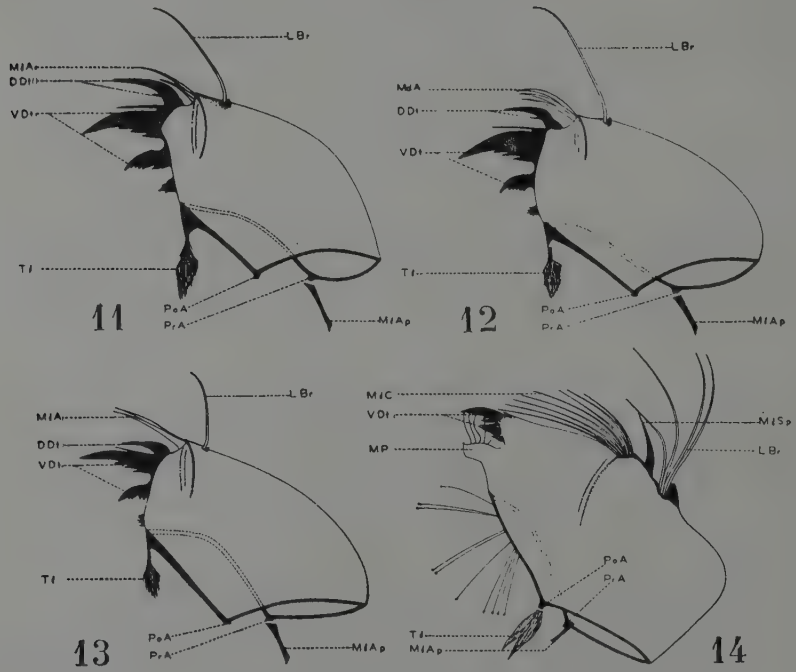
The apodemes of the labral brushes are composed of three invaginations, two labral apodemes (Fig. 9, LAp) and a transverse bar (TB). The labral apodemes are slightly sclerotized and pigmented. Their distal and proximal ends are somewhat pointed. The anterior, medial and posterior processes of the labral apodemes (AAp and PAp) are more slender and slightly pigmented than those of the older instars. There is a small, rounded membranous area which is attached to the middle of the mesal margin of the labral apodeme.

The transverse bar extends transversely on the ental surface of the labrum, between the distal thirds of the labral apodemes. The lateral extremities of the transverse bar are somewhat pointed and attached to the anterior processes of the two labral apodemes. They bend meso-caudad and widen gradually, then they taper again gradually and extend more or less mesad. The two symmetrical halves of the transverse bar fuse with each other at the meson. The presence of the transverse bar here and its absence in the third and fourth instars, presents another

taxonomic feature, which helps differentiation between the second and the older instars of this species.

The epipharynx

The epipharynx (Fig. 9, Ep) looks more like those of the filtering or grazing feeding larvae. It is composed of the epipharyngeal sclerite (EpSc) and the epipharyngeal hairs (EpH). The epipharyngeal processes, which occur in the third



FIGS. 11-14: Ventral aspect of the left mandible of the (11) fourth, (12) third, (13) second, and (14) first instar larva, respectively.

and fourth instars, are here absent. The epipharyngeal sclerite is slightly sclerotized and arched caudad in the mesal region. The lateral extremities of the epipharyngeal sclerite are connected with the small membranous areas which are attached to the middle of the mesal margin of the two labral apodemes. The epipharyngeal hairs are simple, fine, relatively long and lightly coloured; thus differing from the brush-like hairs of the advanced instars. They are long mesad and shorten gradually laterad. They tangle and overlap each other, forming a sieve-like structure. The

epipharynx in this respect helps to distinguish between the second and the older instars of this species. In the larva of *P. ciliata*, the epipharynx of the second instar is, to a great extent, similar to that of the third and fourth instars (SHALABY, 1957c).

The mandibles

The mandibles (Figs. 13 and 17) are adapted for the predacious feeding habit. They are less sclerotized and less pigmented than in the advanced instars. The ventral group of dentes (VDt) is composed mainly of a cephalic serrated tooth and a caudal serrated tooth. There is a sclerotized area near the caudal end of the mesal margin which is produced into six small teeth-like projections. The serrations of the cephalic tooth are three in number. The serrations of the caudal tooth are four in number, while those in the older instars are six in number. The needle-like tooth which arises from the cephalic region of the base of the cephalic serrated tooth, is comparatively short, slender and lightly coloured. The dorsal group of dentes (Figs. 9 and 17, DDt) is composed of two teeth, a large tooth and a small tooth which are shorter, more slender and less pigmented than in the advanced instars. There is only one small spine-like tooth (Fig. 17, Th) located at the mesal region of the dorsal aspect of the mandible. There are only two mandibular arms (Figs. 13 and 17, MdA) which are sharply pointed, lightly coloured and slightly curved.

The meso-caudal margins of the mandible are sclerotized and pigmented along their entire length. The mandible is articulated to the ventral wall of the head by means of the preartis and the postartis (PrA and PoA). The articulation is strengthened by means of the mandibular apodeme (MdAp) which is more slender and less sclerotized than in the older instars. The lateral bristle (LBr) is slightly curved, slender, short and lightly coloured. It extends meso-cephalad.

The mandibular comb (Fig. 17, MdC) is composed of eight setae which are shorter and lighter coloured than those of the advanced instars. The sclerite bearing the comb (ScC) is slender and lightly pigmented.

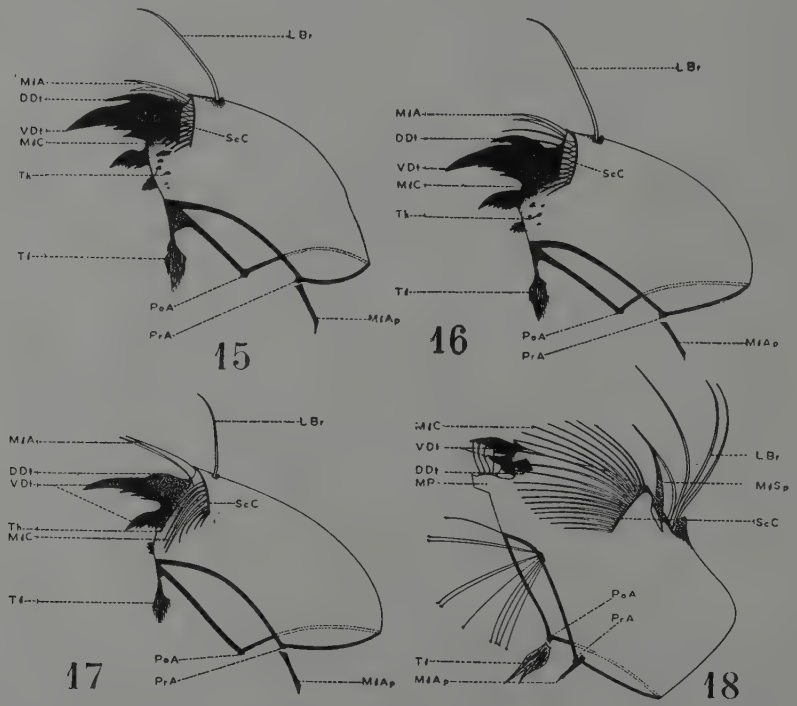
The maxillae

The maxillae (Fig. 22) are comparatively small in size. As in the older instars, each maxilla is composed of the galea (Ga), the lacinia (Lc), the cardostipes (CdSt), the maxillary palpus (MxP) and the palpifer (Pf.) The meso-caudal margin of the maxilla is provided with a few and short setae which are less rigid than those of the older instars. The chitinous ridge (CR) is more slender, less pigmented and more sharply curved than that of the third and fourth instars.

The maxilla is articulated to the ventral wall of the head by means of the entoparartis and the exoparartis (Enp and Exp). The maxillary palpus (MxP) is comparatively short and lightly coloured, with four sensoria (S) at its distal end. It is noticed that the suture that separates the palpifer (Pf) from the palpus is not

apparent. The microspines (MSp) which arise on the latero-cephalic margin are small, lightly coloured and fewer than in the third and fourth instars. The maxillary spine (MxSp) is proportionally long and extends cephalo-laterad. It is less rigid and lightly coloured.

The three maxillary combs (MxC) are composed of numerous and more or less rigid setae. These setae are fewer, less rigid and lighter coloured than those of the older instars. The small needle-like spine which arises from the lacinia in the third and fourth instars, is here absent. The maxilla of the second instar is, to a great extent, similar to that of the third and fourth instars.



FIGS. 15-18: Dorsal aspect of the right mandible of the (15) fourth, (16) third, (17) second, and (18) first instar larva, respectively.

The labium

The labium is composed of the submentum, mentum and the paraglossa. There is no illustration here for the submentum because of its similarity to the

submentum of the fourth instar larva with the exception of the size and the degree of pigmentation.

The mentum (Fig. 26) is smaller in size, less sclerotized and less pigmented than that of the third instar. The meso-cephalic end of the mentum is provided with four to five teeth (Th) which are somewhat pointed and lightly pigmented. The transverse ridge which runs transversely across the middle of the menta of the third and fourth instars is here absent.

The paraglossa (Fig. 30) is comparatively small. It is composed of 16 teeth, eight teeth on the left side, seven teeth on the right side and a disto-central tooth. The teeth are equal in number to those of the third instar, though vary in shape and size. It is noted that the teeth on one side are not symmetrical with those of the other side. The caudal sclerotized area which occurs at the meso-caudal region of the paraglossa in the third and fourth instars is here absent.

The hypopharynx

The hypopharynx (Fig. 34) is more or less oval in shape, while that of the older instars is roughly triangular. It is comparatively small in size, lightly sclerotized, lightly pigmented and not bilaterally symmetrical. The author was not able to trace the salivary ducts in this instar. The hypopharyngeal spines (HypSp) are fewer, smaller, and lighter coloured than those of the older instars. The majority of these spines are arranged along the cephalic transverse region of the hypopharynx. The two hypopharyngeal processes (HypP) are relatively large and pigmented. Like those of the older instars, the movable spines (MvSp) are four pairs, two pairs on each side. They are shorter and more slender than in the older instars.

VI. THE MOUTH PARTS OF THE FIRST INSTAR LARVA

The head capsule of the first instar larva is about 0.485 mm. in width. It is oval in shape. The larva in this instar is not predacious. It practices the filtering method of feeding. It is characterized by the presence of an egg burster on the dorsum of the frons.

The labrum

The labrum (Fig. 5, Lr) is composed of the palatum and the labral brushes. Unlike that of the older instars, the labro-clypeal suture (LCS) is curved caudo-laterad and extends all the way to the sides of the head. In this instar, the fronto-clypeal suture is absent and leads to the fusion of the postclypeus and the frons forming the fronto-postclypeus (FPc). The preclypeus (Prc) extends caudo-laterad and becomes invaginated on the sides of the head to form the paraclypeal phragmata (Figs. 5 and 10, PrPh). The three pairs of frontal hairs (Fig. 5, FH) are slender, short and lightly coloured.

The egg bruster (Fig. 6, EB) resembles, to a great extent, that of *P. ciliata* (SHALABY, 1957c). It contains a transverse pigmented area with a heavily pigmented spine in its center. The spine pushes against the chorion of the egg during the hatching process.

The palatum (Figs. 5 and 10, Pl) resembles, to some extent, that of the second instar. It is more or less membranous and roughly lunate. The palatal hairs (PlH) arise from the margin of the palatum. They are short and fine. The palatum is clothed with numerous fine and short hairs on its ectal surface.

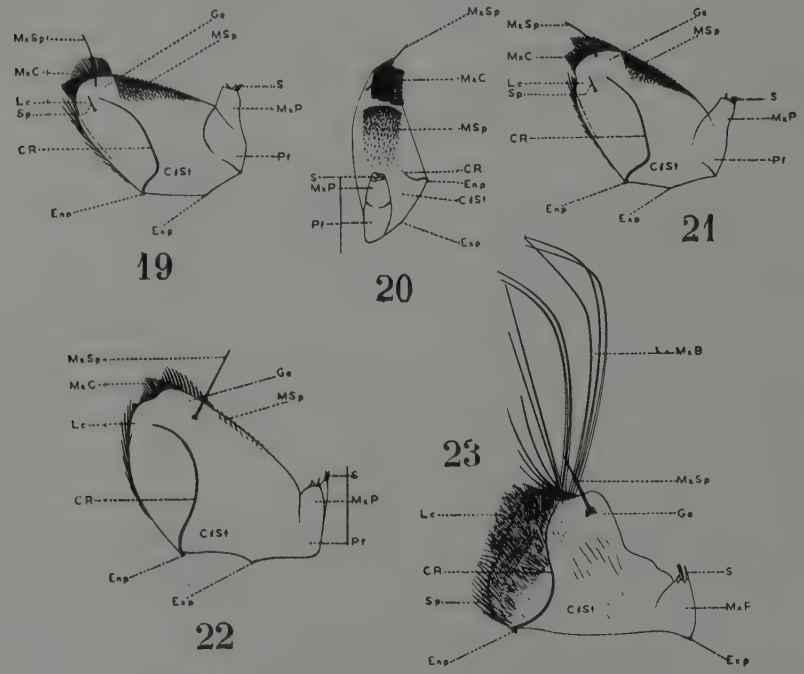


FIG. 19: Ventral aspect of the left maxilla of the fourth instar larva. — FIG. 20: Lateral aspect of the left maxilla of the fourth instar larva. — FIGS. 21-23: Ventral aspect of the left maxilla of the (21) third, (22) second, and (23) first instar larva, respectively.

The labral brushes (LB) consist of numerous hairs which are shorter and finer than those of the advanced instars. Because of the filtering-feeding habit, the hairs of the labral brushes (Fig. 39, HLB) are simple and not serrated. Each labral brush is composed of four groups of hairs. The first group consists of numerous hairs which are relatively long, fine, curved and extend latero-cephalad. This group arises along the entire length of the hair-bearing sclerite (Figs. 5 and 10, HSc)

The second group arises from the distal end of the hair-bearing sclerite. It consists of a small number of hairs, which are slightly curved, relatively short and extend meso-cephalad. The third group arises from the curved distal part of the hair-bearing sclerite. The hairs of this group are short, fine, slightly curved and overlap those of the opposite side, thus covering the ental surface of the palatum. The fourth group is located on the ental aspect of the palatum. It consists of a considerable number of hairs which are relatively longer and darker coloured than those of the third group.

The apodemes of the labral brushes are composed of two labral processes (Fig. 10, LAp), two lateral labral plates (LLP) and a transverse bar (TB). They thus, resemble those of the filtering or the grazing feeding larvae. The distal end of the labral apodeme is somewhat pointed and bends cephalo-laterad to fit into the middle of the mesal margin of the hair-bearing sclerite. The anterior process of the labral apodeme (AAp) is small, triangular in shape and attached to the proximal end of the mesal margin of the distal third of the labral apodeme. It extends meso-cephalad. The medial process of the labral apodeme (MAp) is attached to the lateral margin of the medial third of the labral apodeme. It is triangular shaped, sharply pointed and extends latero-caudad. The posterior process of the labral apodeme (PAp) is connected with the distal end of the proximal third of the labral apodeme, as in the older instars. It is slightly sclerotized, lightly pigmented and extends meso-caudad. As in the advanced instars, there is a small membranous area which is attached to the distal end of the mesal margin of the proximal third of the labral apodeme.

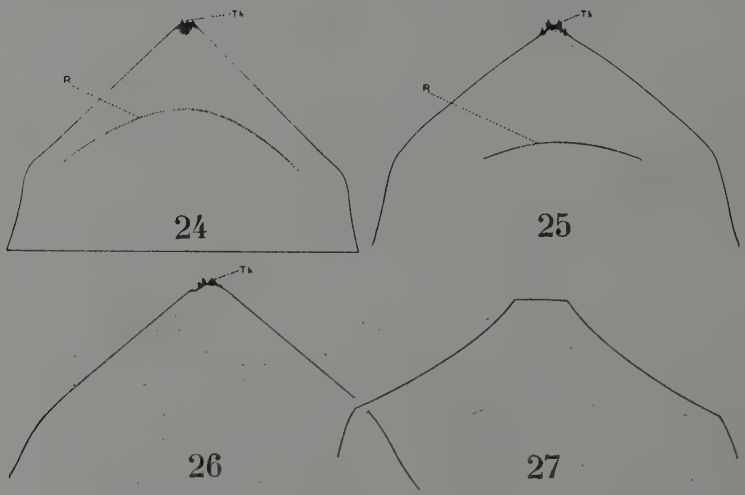
Each lateral labral plate is located between the hair-bearing sclerite and the distal third of the labral apodeme. It is triangular in shape, very lightly pigmented and slightly sclerotized. The transverse bar extends transversely on the ental surface of the labrum between the anterior processes of the labral apodemes. The two symmetrical halves of the transverse bar fuse with each other at the meson to form a notched structure. The lateral parts of the transverse bar are slender and lightly pigmented; then they widen gradually meso-caudad and taper again to become more pigmented mesad. Therefore, the apodemes of the labral brushes provide an important feature which helps to differentiate between the first and the older instars.

The epipharynx

The epipharynx (Fig. 10, Ep) is composed of the epipharyngeal sclerite (EpSc) and the epipharyngeal hairs (EpH). The epipharyngeal sclerite is very slender, lightly pigmented and produced mesally into a small, oval shaped and lightly pigmented process (EpP) which is attached to the caudal margin. It must be noted that this process is absent in the older instars, while the spine-like epipharyngeal processes of the third and fourth instars are absent in this instar. The epipharyngeal hairs are simple, considerably few, short and lightly coloured.

The mandibles

The mandibles (Figs. 14 and 18) are adapted for the filtering method of feeding. They look more like those of *Anopheles quadrimaculatus*, *Culex quinquefasciatus* and *Aedes aegypti* (SHALABY, 1956 and 1957, a and b), than those of the older instars of the same species. Each mandible is roughly quadrangular in shape. The ventral group of dentes (VDt) consists of seven short and lightly coloured dentes which vary in size. The dorsal group of dentes (Fig. 18, DDt) is composed of a single dent which is sharply pointed and slightly pigmented. It must be noted that the mandibular arms which occur in the mandibles of the advanced instars, are absent here.



FIGS. 24-27: Ventral aspect of the mentum of the (24) fourth, (25) third, (26) second, and (27) first instar larva, respectively.

Like the mandibles of the filtering feeding mosquito larvae, a membranous process (Figs. 14 and 18, MP) is located caudad of the dentes-bearing area. Arising from the cephalic margin of the membranous process are five lightly coloured and relatively long hairs. The mesal margin of the mandible is sclerotized and pigmented along its proximal two-thirds. Arising from the distal region of the mesal margin are about ten hairs which form a fan-shaped structure. Each hair ends distad into a few short branches.

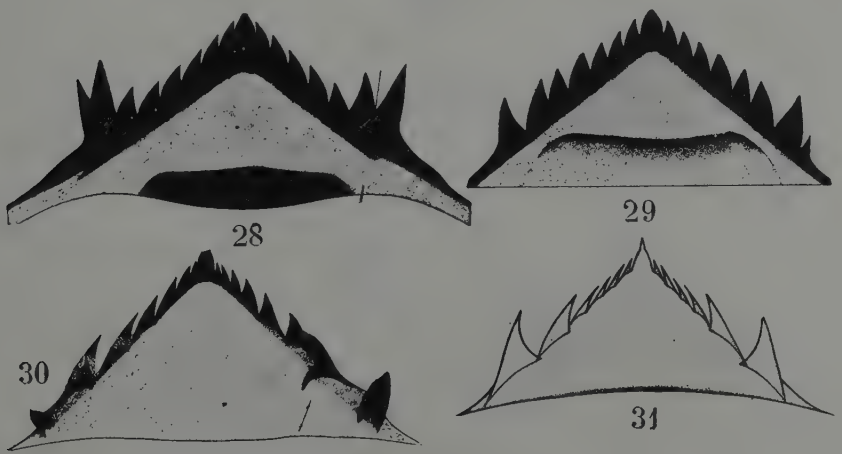
The mandible is articulated to the ventral wall of the head by means of the preartis and the postartis (PrA and PoA). The articulation is strengthened by means of a mandibular apodeme (MdAp). The lateral margin of the mandible is sharply curved and ends distad in a projecting sclerotized and pigmented socket

which bears four lateral bristles (LBr) that vary in length. Arising from the latero-cephalic region of the dorsal aspect of the mandible is a lightly pigmented mandibular spine (MdSp). It is lacking in the older instars.

The mandibular comb (MdC) is comparatively large in size. It is composed of long setae which range from 18 to 22 in number. This comb resembles the brush found in the mandibles of the filtering feeding larvae. The setae of the comb arise on a relatively slender and pigmented sclerite (Fig. 18, ScC). The mandible of the first instar, therefore, is admirably adapted for the filtering feeding method. It presents a significant taxonomic character which helps to distinguish between the first and the more advanced instars.

The maxillae

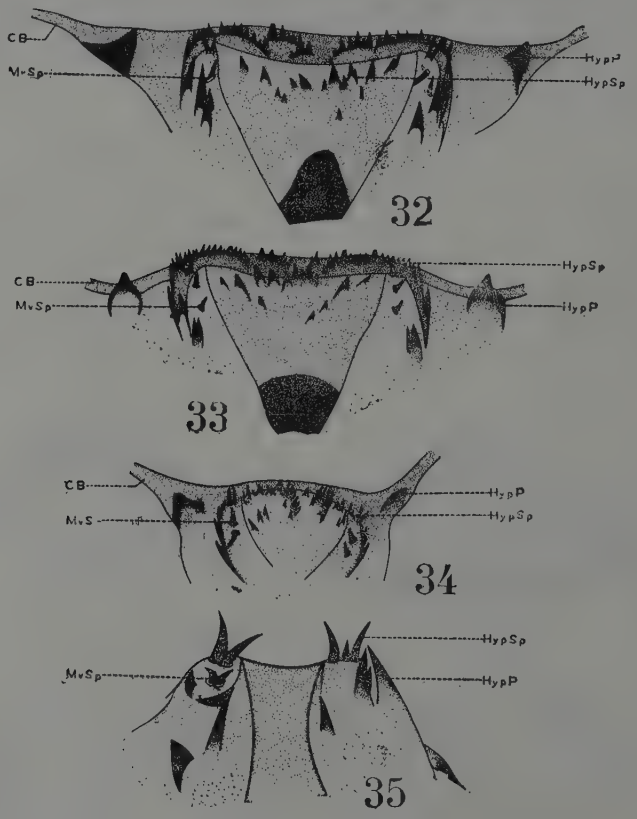
The maxillae (Fig. 23) are adapted for the filtering feeding habit of the larva. They look like those of the larvae of *Aedes aegypti* and *Culex quinquefasciatus* (SHALABY, 1957a and b). It is apparent that the palpifer is fused with the maxillary palpus (MxP). The mesal margin of the maxillae is slightly sinuate. It is provided with numerous hairs and spines (Sp) which arise from its proximal half, and extend meso-cephalad. The entire mesal region is clothed with a great number of hairs which extend in all directions.



FIGS. 28-31: Ventral aspect of the paraglossa of the (28) fourth, (29) third, (30) second, and (31) first instar larva, respectively.

The chitinous ridge (CR) is slightly sinuate. It is proportionally longer, but lighter coloured than in the older instars. As in the advanced instars, the maxilla is articulated to the ventral wall of the head by means of the entoparartis and the

exoparartis (Enp and Exp). On the distal end of the maxillary palpus are four sensoria (S) which are proportionally long and lighter coloured than those of the older instars. The lateral margin of the maxilla is sinuate. It must be noted that the microspines which arise from the latero-cephalic margin of the maxillae of the older instars are absent here. The maxillary spine (MxSp) which arises from the cephalic region of the galea (Ga) is relatively longer, stouter and extends meso-cephalad.



FIGS. 32-35: Ventral aspect of the hypopharynx of the (32) fourth, (33) third, (34) second, and (35) first instar larva, respectively.

It is noticeable that the maxillary combs which occur in the advanced instars are absent here, and instead there is a maxillary brush (MxB) which is attached to the cephalic end of the maxilla. The maxillary brush is composed of about 12 to 15 hairs which are elongate, sharply pointed and curved meso-cephalad. The short

needle-like spine which arises from the cephalic region of the lacinia in the third and fourth instars, is absent here. The maxilla in this respect is helpful in distinguishing between the first and the older instars.

The labium

The labium is composed of the submentum, the mentum and the paraglossa. There is no illustration for the submentum here, because of its similarity to that of the fourth instar, with slight differences in the shape besides the difference in the size.

The mentum (Fig. 27) is roughly triangular in shape, small, slightly sclerotized and lightly coloured. It must be noted that the teeth which arise on the meso-cephalic region of the menta in the older instars, are lacking here.

The paraglossa (Fig. 31) is smaller in size, less sclerotized and less pigmented than that of the advanced instars. It is composed of 13 teeth, with six teeth on each side of the disto-central tooth. The teeth are hard to see with the dissecting microscope. The paraglossa presents another taxonomic character which helps to distinguish between the different instars.

The hypopharynx

The hypopharynx (Fig. 35) is more or less quadrangular in shape and entirely different in shape from that of the predacious feeding instars. It is not bilaterally symmetrical. The author has not been able to trace the salivary ducts or to spot the salivary opening. The hypopharyngeal spines (HypSp) are about 15 in number, but proportionally larger than those of the older instars. There is only one hypopharyngeal process (HypP) on the left side. There are a few movable spines (MvSp) located on the right side of the hypopharynx and none on the left side. The hypopharynx presents an additional taxonomic character which helps to distinguish between the first and the advanced instars.

VII. SUMMARY OF THE IMPORTANT INSTAR DIFFERENCES

The egg-burster is present only in the first instar (Fig. 6, EB).

The labral brushes of the first instar (Figs. 5 and 10, LB) are composed of simple hairs and each labral brush consists of four groups of hairs. The labral brushes of the second instar (Figs. 4 and 9, LB) are composed of serrated hairs, and consist of three groups of hairs each. In the third and fourth instars (Figs. 2 and 3, LB), each labral brush consists of one group of serrated hairs.

The palatum of the first instar (Figs. 5 and 10, Pl) is lunate, membranous and is provided with short palatal hairs along its margin. The palatum of the second

instar is narrow and contains no palatal hairs. In the third instar, the palatum (Figs. 3 and 8, Pl) is rectangular, with 12 palatal hairs. The palatum of the fourth instar (Figs. 2 and 7, Pl) is rectangular, with 16 palatal hairs.

The apodemes of the labral brushes in the first instar consist of two labral processes, two lateral labral plates, and one transverse bar (Fig. 10, LAp, LLP and TB). In the second instar, the apodemes of the labral brushes lack the lateral labral plates. In the third and fourth instars, these apodemes are composed only of two labral apodemes (Figs. 7 and 8, LAp). The writer believes that the second instar, although it is not proved, may practice the filtering or the grazing feeding habit along with the predacious method.

The epipharyngeal hairs of the first instar (Fig. 10, EpH) are few, short and simple, while those of the second instar (Fig. 9, EpH) are numerous, relatively long and also simple. In the third and fourth instars, the epipharyngeal hairs (Figs. 7 and 8, EpH) are brush shaped.

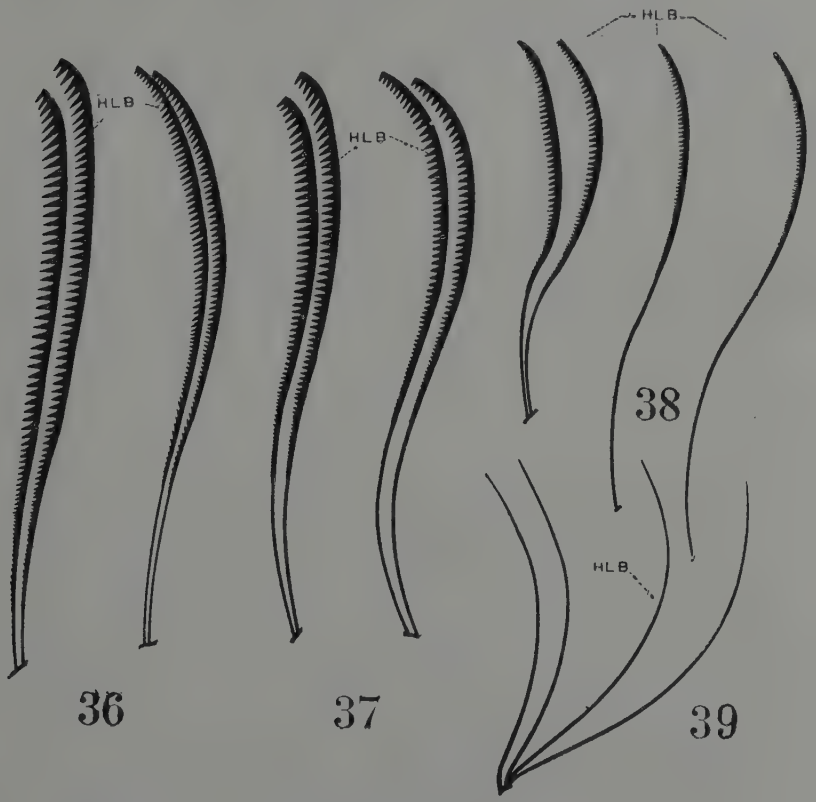
The ventral dentes of the mandible of the first instar (Figs. 14 and 18, VDt) are short, lightly pigmented and seven in number. Those of the predacious feeding instars (Figs. 11, 12 and 13, VDt) are composed mainly of two strong serrated teeth. The dorsal dentes of the first instar (Fig. 18, DDt) consist of one short dent. Those of the predacious feeding instars (Figs. 11, 12 and 13, DDt) consist of two curved dentes, a large tooth and a small tooth. The membranous process is present in the mandible of the first instar (Figs. 14 and 18, MP), but absent in the mandibles of the older instars. The lateral bristles are more than one in the mandibles of the first instar (LBr) and only one in the advanced instars. The mandibular comb of the first instar (Fig. 18, MdC) is composed of 20 elongate and lightly pigmented setae. That of the second instar (Fig. 17, MdC) is composed of eight setae. In the third and fourth instars, the mandibular comb (Figs. 15 and 16, MdC) is composed of ten relatively long and pigmented setae.

The maxilla of the first instar (Fig. 23) is roughly triangular, with a maxillary brush (MxB) attached to its cephalic end. After the first moult, the maxilla loses its maxillary brush which becomes replaced by three short maxillary combs in the second, third and fourth instars (Figs. 19, 20, 21 and 22, MxC).

The mentum of the first instar (Fig. 27) is more or less membranous, with no teeth at its meso-cephalic end. After the first moult, the mentum develops about five short and somewhat pointed teeth (Fig. 26) at its meso-cephalic end. After the second moult, the mentum develops a short transverse ridge (Fig. 25, R) across its middle, and the teeth (Th) increase to about six in number. After the third moult, the ridge becomes wider and longer and the teeth (Fig. 24, R and Th) increase to about eight in number.

The paraglossa of the first instar (Fig. 31) is composed of 13 teeth, six teeth on each side of the disto-central tooth. The paraglossa of the second instar (Fig. 30) consists of 16 teeth, eight teeth on the left side, seven teeth on the right side and a

disto-central tooth. The paraglossa of the third instar consists of 16 teeth which are more sclerotized and pigmented than in the second instar (Fig. 29). In the fourth instar, the paraglossa (Fig. 28) is hightly sclerotized and with 16 teeth also; but with seven teeth on the left side, eight teeth on the right side and a disto-central tooth. There are some variations in the number of teeth among different specimens of the same instar.



FIGS. 36-39: Hairs of the labral brushes of the (36) fourth, (37) third, (38) second, and (39) first instar larva, respectively.

The hypopharynx of the first instar (Fig. 35) is quite small, lightly sclerotized and with a few hypopharyngeal spines (HypSp). The hypopharynx of the second instar (Fig. 34) is roughly oval in shape and includes numerous spines. These spines increase gradually in number, size, degree of sclerotization and degree of pigmentation in the third and fourth instars (Figs. 32 and 33, HypSp).

VIII. KEY TO THE LARVAL INSTARS OF *PSOROPHORA HOWARDI* (COQUILLETT) BASED ON THE HEAD STRUCTURES

1. Larva with predacious feeding habit. Egg burster absent. Hairs of labral brush serrated. Head more or less quadrate. Ventral dentes of mandible serrated. Membranous process of mandible absent. Maxilla oval in shape, with no maxillary brush. Mentum with teeth at its meso-cephalic region. Paraglossa with 16 teeth or more, and heavily sclerotized. Hypopharynx with numerous spines. **2**

1a. Larva with filtering feeding habit. Egg burster present. Head rounded and about 0.485 mm. in width. Hairs of labral brush simple. Labral brush with four groups of hairs. Labral brushes with two labral apodemes, two lateral labral plates and a transverse bar. Palatum lunate with numerous short palatal hairs. Ventral dentes of mandible not serrated. Membranous process of mandible present. Lateral bristles of mandible four. Maxilla triangular in shape with a maxillary brush. Mentum with no teeth at its meso-cephalic region. Paraglossa small, lightly sclerotized and with 13 teeth. Hypopharynx lightly sclerotized, quadrangular in shape, and with a few hypopharyngeal spines ..... **First instar**

2. Labral brush with one group of hairs. Transverse bar on the ental surface of labrum, absent. Epipharyngeal hairs brush-like..... **3**

2a. Labral brush with three groups of hairs. Transverse bar present. Epipharyngeal hairs simple. Head about 0.552 mm. in width. Palatum oval in shape with no palatal hairs. Ventral dentes of mandible serrated. Mandibular comb with 8 setae. Maxilla oval in shape, with three maxillary combs. Microspines on latero-cephalic margin of maxilla few. Mentum with five somewhat pointed and lightly coloured teeth at meso-cephalic region. Paraglossa with 16 teeth and lightly sclerotized. Hypopharynx oval in shape, slightly pigmented and with about 45 hypopharyngeal spines ..... **Second instar**

3. Head sclerotized, pigmented and about 0.937 mm. in width. Mesal hairs of labral brush serrated along the distal three quarters of their mesal margin. Palatal hairs 12, six on each side. Maxillary combs lightly coloured. Microspines on latero-cephalic margin of maxilla. Mentum with about six sharply pointed and pigmented teeth at its meso-cephalic region. Paraglossa sclerotized and with 16 teeth, eight on the left side, seven on the right side and a disto-central tooth. Hypopharynx roughly triangular, sclerotized, pigmented and with about 65 hypopharyngeal spines ..... **Third instar**

3a. Head heavily pigmented and about 1.372 mm. in width. Mesal hairs of labral brush serrated along almost the entire mesal margin. Palatal hairs 16, eight on each side. Microspines on latero-cephalic margin of maxilla very numerous and pigmented. Mentum with about eight sharply pointed and heavily pigmented teeth at its mesocephalic region. Paraglossa highly sclerotized and heavily pigmented and with 16 large teeth, seven on the left side, eight on the right side and a disto-central tooth. Paraglossa with a heavily pigmented sclerite at caudal region. Hypopharynx roughly triangular, highly sclerotized, heavily pigmented and with 65 or 70 hypopharyngeal spines **Fourth instar**

IX. ACKNOWLEDGMENTS

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FIELD TESTS ON THE USE OF A POLYHEDROSIS VIRUS DISEASE FOR THE CONTROL OF THE COTTON LEAF-WORM, *PRODENIA LITURA* F.

(with 3 Tables)

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I. INTRODUCTION

HUGHES (1957), gave a list of about 200 species of insects that are reported to be infected with virus diseases. More than 150 of the listed ones are lepidopterous larvae and the virus diseases are mostly of the polyhedrosis type.

In a previous paper (ABUL-NASR, 1956) the author studied the characteristics and effect of an indigenous polyhedrosis-virus disease that infects the cotton leaf-worm *Prodenia litura* F., under laboratory conditions.

FLASCHENTRAGER et al (1958) have found that breeding of 55.000 *Prodenia litura* larvae in the laboratory has yielded only 20% of moths; the rest died while on the larval or pupal stages. These authors believe that death was mostly due to virus infection.

BERGOLD and FLASCHENTRAGER (1957) worked on the polyhedral bodies and the virus particles of the polyhedrosis-virus disease of *Prodenia litura*. The latter authors caused the virus-dead larvae to dry in a desiccator and then be suspended in water for some weeks. They found the polyhedra to be of irregular shape and their diameter to vary from 1.2 to 3.2 M. To the author's experience the long suspension of polyhedra in water (for some weeks) is responsible for the distortion and irregular shape of the polyhedral bodies. The different sizes of the polyhedra may be related to different developmental stages of the virus disease in the tested material.

HAFEZ (1958) gave an account on the polyhedrosis virus disease of the cotton leaf-worm *Prodenia litura* F., in Egypt, but his laboratory and field tests were inadequate.

STEINHAUS (1949) stated that on frequent occasions a polyhedrosis-virus disease breaks out among the larvae of *Prodenia praefica* Grote, and may destroy large numbers of them. The same author found that *Prodenia ornithogalli* Guén., is also subject to attack by a polyhedral virus. BLANCHARD and CONGER (1932) stated that the polyhedral disease was the most important factor in natural control of *Prodenia praefica.* The author agrees with the opinion of THOMPSON and STEINHAUS (1950) that "Recommendations to the general use of the virus as a means of practical control of the caterpillars cannot be made until further tests have been completed. In any case, its use will probably require competent supervision by trained entomologists".

The present work is a contribution in the effort to solve the problem of combating the cotton leaf-worm in Egypt. It is also an evaluation of the validity of the method of controlling insect pests through "microbial control".

II. PROCEDURE

Cotton leaf-worms were bred in the laboratory from the egg batches that were collected from the field since the last week of May. The egg batches were laid in muslin bags together with clover bouquets and kept there until the hatched larvae reached the third instar, providing them with fresh bouquets twice daily. Then the larvae were transferred to the breeding cages until they were fully grown.

Many of the tiny larvae were continuously escaping from the muslin bags by gnawing their exit holes through the cloth. In the breeding cages many of the grown larvae dwindled for no obvious reason, except for conditions under captivity. Microscopical inspection revealed the presence of putrefying bacteria of bacillus type in the smears of such larvae.

Grown larvae were offered contaminated food that was sprayed with virus suspension. After three days the larvae that carried the premortal symptoms were segregated and later their liquified bodies were collected in glass jars. Great care should be taken to distinguish between the virus infected and the non-virus infected larvae. The experienced eye can easily distinguish between the two kinds by the colour of the ventrum, the condition of the skin, the degree of liquifaction, and the colour of the inside contents. In the case of the virus infected larva the colour of the ventrum is pale with definite pinkish shadow, the skin is so fragile that it bursts under any slight handling, the liquifaction is so complete that the contents, when fresh, become thin and watery and light brown in colour with a pinkish tinge. The change of colour of the virus inflicted larvae was also observed in *Prodenia praefica* which may turn reddish-brown before death (STEINHAUS,

1949, p. 467). In the case of non-virus infected larva, the ventrum is grayish-green, the skin keeps intact under pressure, the liquifaction is not complete and the colour of the contents is dark brown or greenish. When the bodies of virus-infected larvae are collected in a jar they form a homogenous light brown paste with hardly any trace of larval skeletons. In the case of non-infected larvae the collected material is not homogenous as many bodies keep their skin and the colour is dark gray or green.

In this connection it is worth mentioning that all dead larvae that were collected from virus-treated plants in the field showed typical virus infection.

Most of the grown larvae that were collected from the field and were offered contaminated food escaped the infection by turning into pupae, even if they were of the fourth or fifth instars. A phenomenon was reckoned by STEINHAUS (1949) when he states that "It would be of great biological interest to know just what takes place in the tissues of insects to change their susceptibility to insusceptibility as they reach the adult stage".

The original virus material, that is the liquified bodies of virus-dead larvae, was diluted with tap water to the concentrations of 1/500, 1/100, 1/20, 1/10 and the virus suspension was distributed by a knapsack sprayer. Such concentrations of the virus suspension are rather equal to those used by THOMPSON and STEINHAUS (1950) for the control of alfalfa caterpillar in which one milliliter contained 1.000.000, 5.000.000, 25.000.000 and 50.000.000 polyhedral bodies, respectively.

The effect of the disease was estimated by comparing the counts of dead and live larvae on treated and untreated plants.

Dead larvae were always hand-picked, but live larvae were hand-picked or swept by net or shaken from the plants into a bag of cloth.

Four tests were conducted at two different localities in Egypt. The first locality lies at the north region of the Delta at a place called Tafteesh El Khazzan where summer temperature is rather moderate (max. around 33°C.) and the relative humidity runs around 65% during day time and increases until 100% two hours after sunset. This locality is known to have a high population density of *Prodenia* larvae which cause great damage to the cotton plants.

The second locality is the farm of the Faculty of Agriculture in Giza where temperature in summer is hot (max. around 38°C.) and the relative humidity runs around 60% during day time and increases to 80% two hours after sunset.

III. TESTS

Test 1

There were two test plots. The first plot was 30 by 10 metres containing 20 rows of cotton plants and the second plot was 35 by 18 metres containing 37 rows of cotton plants. The plants in the two plots were greatly damaged by a severe at-

tack of the leafworms. The first plot was sprayed on July 13 with five litres of the virus suspension at a concentration of 1/50 of the original virus material. The second plot was sprayed with ten litres of virus suspension at a concentration of 1/100.

During the four days that followed the treatment, the plants were searched for the virus-dead larvae, but the inspection did not yield any of such larvae. The test had to be cancelled and the two test plots were sprayed with Toxaphene.

The apparent negative result of this test can be related to the following reasons:

(1) The treated cotton plants were in a very bad condition, most of the leaves' surfaces were eaten by the caterpillars and only the rigid veins were left. There was very little chance for the virus material to stick on the plants.

(2) Most of the larvae were of the fully grown size and they were hidden inside the blossoms and the bolls, feeding on the inside contents of these parts which were hardly reached by the disease.

(3) It was realized that the time of spraying (2 hours after sunset) might be later than it should have been. Due point was reached shortly after spraying and this caused the virus suspension to be greatly diluted or may be completely washed away.

(4) In spite of the previous three factors that worked against the proper effect of the disease, it was realized in later tests that the symptoms of the disease could have been shown on the larvae, if the plot was left for inspection for a longer period before it had been treated with the chemical insecticide.

In the laboratory, some of the fully grown *Prodenia* larvae succumbed to the effect of the pathogen on the third day after consuming contaminated food (ABUL-NASR, 1956). But most of such larvae died after 4 or 5 days. In the other test plots it became evident that under field conditions a very few of the grown larvae succumb to the effect of the disease after 5 days from spraying the virus disease; the infection becomes quite evident after 8 days and continues to be so for at least two weeks.

Test 2

Test plot was 20 by 18 metres containing 36 rows of plants and the control plot was of equal size. Spraying of the virus suspension took place on July 28, two hours after sunset. Two rows of plants were sprayed with the virus suspension at the dilution of 1/10 of the original virus material, three rows at 1/20 and 31 rows at 1/100 of the original virus material.

The condition of the plants in this test plot was much better than it was in the first test. Before the treatment the plants were infested with 52 *Prodenia* egg-batches. The next day after treatment the number of batches jumped to 120 of which fifty contained recently hatched larvae. Five days after spraying the virus suspension, many of the second instar larvae became yellowish white in colour and were very sluggish, contrary to the healthy larvae of their age which are dark gray

and very active. Some of the suspected tiny larvae were kept under observation and they died next day and their bodies were greatly liquified. In the field it was very hard to detect dead bodies of the second or third instars in the liquified state. After death their tiny bodies would dry up very quickly and be blown away or turn into small black scales stuck to the top leaves as the only remnants of such larvae.

During the two weeks after spraying the virus suspension the condition of infection with *Prodenia* larvae in the treated plot was as follows:

Laying of egg masses continued, hatching of eggs took place successively, plenty of the first instar larvae were found nibbling at the lower surface of the leaves, and some of them were spinning and falling on other parts of the plants. Second and third instar larvae were many but most of them were pale and sluggish. The fourth instar larvae were scarce and most of these carried the symptoms of the affliction. The fifth instar larvae and the fully grown ones were very scarce and carried the premortal symptoms. Counts of larvae of the different instars was determined by shaking 10 plants, chosen at random, into a bag of cotton cloth (Table I).

TABLE I

Counts of Prodenia *larvae collected from 10 plants at two times after treatment*

Larval instars	Length of larvae in mm.	Number of larvae 13 days after spray	Number of larvae 18 days after spray
2nd and 3rd	7-12	143	200
4th	15-20	8	13
5th	25-30	2	9
6th	40-50	2	1

After three weeks from the date of spraying the virus disease, correlation between counts of the different larval instars was overturned. Ten plants were completely free from the tiny larvae of the first and second instars, contained 4 of the third instar, 9 of the fourth instar, and 19 of the fifth and fully grown larvae. At the same time, the spread of the disease infliction among the 5th and 6th instar larvae was quite evident. Dead larvae with full symptoms of the disease were spread over or falling down the leaves, the blossoms and the bolls of the plants. There were up to five dead larvae on a single plant. The plants of the five rows that were sprayed with the virus suspension at the dilutions of 1/10 and 1/20 of the original material contained relatively more of the dead larvae than the other plants of the test. But the difference cannot be considered of a definite significance, and the reason may be that the plants of the different treatments were so close that *Prodenia* larvae were apt to migrate from one place to another in the same plot.

After four weeks from the date of spraying the virus two people were able to collect from the treated plot 90 virus-dead larvae and 60 still alive larvae that carried the premortal symptoms. On the next day all treated plants were carefully searched for larvae and the result was 260 dead larvae and 210 still alive larvae. The collected live larvae were kept under observation and they died on the third day with full symptoms of virus infection.

The count of live larvae in the control plot was either equal to that of the treated plot or even less, but dead larvae were very scarce in the untreated plot. The explanation for the equal number of live larvae in the two plots lies in the fact that both plots were close to each other. Larvae were seen crawling from the control plot to the treated plot, maybe attracted by the smell of the virus suspension. In the breeding cage *Prodenia* larvae are always attracted to the dead body of virus-inflicted larvae and are found to feed on it vigorously. When offered the virus material on a hair brush the larvae eat it quite readily. The virus infested plot usually has a stink smell that can be recognised at quite a distance. It seems that such smell has an attractant appeal, not only on the larvae but also on the moths. The number of egg batches laid on the treated plot was, in most cases, more than that laid on the control plot. Such observations were also realised in Tests 3 and 4 on sweet potatoes and alfalfa late in the season.

Test 3

Test plot was 30 by 10 metres containing 34 rows and the control plot was of equal size. The crop was sweet potatoes that were infested with grown *Prodenia* larvae of the fourth, fifth and fully grown instars. The date of spraying the virus suspension was the first of October, and the time was one hour before sunset, at a dilution of 1/100 of the original material. Virus-dead larvae were not discovered before a week after the date of treatment and from then more virus-dead larvae, mostly of the fifth and sixth instars, were found with their bodies stretched on the upper surface of the leaves of the sweet potatoes. A very few dead larvae were found stuck to the lower surface of the leaves. The degenerated bodies of the virus-dead larvae were haunted by different types of ants, flies (house flies, blow flies and sarcophagid flies) and wasps (mostly *Vespa orientalis* and *Polistes gallica*). It is believed (STEINHAUS, 1950) that these vectors may serve to disseminate the virus mechanically.

The virus-dead larvae were collected daily, since their first appearance, between eight and nine o'clock in the morning. This was done by hand picking and the job was not much trouble as the dead larvae were stretched so plainly on the upper surface of the broad leaves of the sweet potatoes. It was observed that the border plants harbour more of the dead larvae than the middle plants. Counts of the virus-dead larvae suggested that the virulence of the disease has reached its climax, under the then prevalent weather condition, on the tenth day after the date

of treatment and continued, more or less, on the same level for about a week after which the virulence started to decline gradually (Table II). Actually, the count of the virus-dead larvae should not be considered as an accurate means for measuring the virulence of the disease since the count of larvae is correlated with the population density of *Prodenia* larvae, the life span of which ranges, during summer time, between two and three weeks. After a month from the date of spraying the virus suspension there were still a few larvae dying from the virus affliction. The phenomenon about the migration of larvae from the non-treated control plot to the treated test plot, previously suspected in Test 2, also occurred in this case. In spite of all the dead larvae that were found in the test plot, the count of live larvae in the control plot slightly overran that in the test plot. Nevertheless, most of the live larvae that were collected from the treated plot were suffering the ailment of the disease while most of those larvae in the control plot were healthy.

TABLE II

Counts of virus-dead larvae and live larvae in the treated plot and the control plot in Test 3.

Date: October 1957	Test plot		Control plot	
	Virus dead larvae	Live larvae	Virus dead larvae	Live larvae
1	—	30	—	38
2	—	34	—	36
5	3	40	—	44
7	41	42	—	45
10	126	50	4	56
12	130	55	1	60
14	112	46	3	48
16	116	31	2	30
19	94	22	1	31
22	58	15	—	22
24	25	11	—	15
30	12	8	—	13

Counts of the live larvae in Table II include only those larvae that were hand-picked from the leaves of the plot plants and so they could not represent the real condition of *Prodenia* infestation. Still comparison of such counts is a certain phase of the pest fluctuation.

Test 4

Test plot was 42 by 37 metres and the control plot was 37 by 12 metres and lay on the two sides of the test plot. The crop was alfalfa and the date of spraying the virus suspension was 15th of October, 1957. The test plot was sprayed with

ten litres of the virus suspension at the dilution of 1/500 of the original virus material. A few of the virus-dead larvae (of the 2nd and 3rd instars) appeared on the fifth day after treatment. The number of the virus-dead larvae that were picked daily from the plants of the test plot increased gradually from the seventh day till the twelfth day after treatment, then the number declined gradually until 35 days had elapsed after which the alfalfa was chopped (Table III). Counts of live larvae on the alfalfa were made by net-sweeping of the whole area under estimation after collecting the virus-dead larvae. Young larvae of the first three instars are found on the plants at day time but older larvae are usually found on the ground around the plants stems. Collecting of larvae took place between 8 and 9 in the morning. Sick grown larvae were discovered crawling slowly on the alfalfa stems during day time.

TABLE III

Counts of virus-dead larvae and live larvae in equal sized land (37 by 12 metres) of treated and control plots in Test 4.

Date in 1957	Test plot		Control plot	
	Virus dead larvae	Live larvae	Virus dead larvae	Live larvae
Oct. 15	—	450 (1 and 2)	—	429 (1 and 2)
,, 18	—	512 (1 and 2)	—	465 (1 and 2)
,, 20	28	510 (2 and 3)	—	526 (2 and 3)
,, 22	108	472 (2 and 3)	—	576 (2 and 3)
,, 24	263	188 (2,3and4)	—	451 (2,3and4)
,, 27	235	176 (3 and 4)	—	473 (3 and 4)
,, 30	196	84 (4 and 5)	4	341 (4 and 5)
Nov. 2	154	120 (4 and 5)	—	305 (4 and 5)
,, 4	110	154 (4 and 5)	2	292 (4 and 5)
,, 7	160	73(full grown)	10	205(full grown)
,, 10	60	46 (,,)	—	156 (,,)
,, 15	9	24 (,,)	—	167 (,,)
,, 20	4	12 (,,)	—	130 (,,)

Numbers in brackets indicate the larval instars.

The larvae that died due to virus infection were of all instars, starting from the second instar to the fully grown larvae. In a few cases larvae in their first skin were also discovered. In this test it was possible to find the dead bodies of the tiny larvae on alfalfa. The weather heat was less than it was in Test 2 and the small larvae were always found on the top sprigs of alfalfa and so it was easy to discern them. In the case of cotton plants the leaves are broad and waxy and the small larvae are usually found on the lower surface of the leaves. Also searching for the dead larvae on alfalfa was carried out twice in the same day. The dead bdoies of

the first two instars were very pale (nearly white with yellowish tinge) and a few hours after death they became so liquified that it was impossible to dislodge them without causing them to burst and ooze whitish fluid.

Before spraying the virus suspension the alfalfa was infested with *Prodenia* egg batches and with larvae of the first and second instars. The population of the small live larvae that were collected by net sweeping from an area of 37 by 12 metres was 450 larvae in the test plot and 429 larvae in the control plot on the day of treatment. Sweeping of live larvae took place after collecting the virus-dead larvae, and the collected live larvae were returned to their sites after having been counted.

Larval population of the first three instars increased slightly during the first week that followed the date of treatment, in both the test plot and the control plot. On the tenth day after treatment the live larval population in the test plot fell down remarkably and continued to fall down during the six days that followed. During the same period the larval population in the control plot fell down very slightly. Then the larval population in the test plot started to rise instead of keeping falling down. The reason was that migration of the fourth and fifth instar larvae from the control plot and from other land under alfalfa began to take place. The phenomenon that was suspected in Test 3 on sweet potatoes was distinctly observed in the case of alfalfa. *Prodenia* larvae were seen creeping on the ground, even at day time, heading for the treated plot, crossing in its way a land under Sudan weed (4 feet high) and a dry trough. Such migration caused upset to the estimation of the disease virulence. If it were not for the migration of larvae the disease could have kept *Prodenia* infestation in the treated plot under complete control in two weeks time after treatment. Nevertheless, the live larval population in the treated plot was still much less than it was in the control plot until alfalfa was chopped 35 days after treatment.

Another factor that caused underestimation of the disease virulence was the taking away of the bodies of the virus-dead larvae for the purpose of counting. These could have been left behind, after having been marked, as a source of fresh and virulent virus material.

VI. DISCUSSION

After discovering a polyhedrosis virus disease that infects *Prodenia litura* F. larvae, the characteristics of the disease was studied carefully under laboratory conditions (Abul-Nasr, 1956). In 1957, the author used the virus-disease in four tests in the field to recognize its virulence for the control of the pest. One of the difficulties was faced through breeding *Prodenia* larvae in the laboratory for the purpose of obtaining the virus material. The author is now convinced that the best way is to spray the virus suspension on clover plants in the field which should

be heavily infested with *Prodenia* larvae of the third and fourth instars. After a week hundreds of virus-dead larvae can be collected daily.

It was planned to use the water virus-suspension at different concentrations of the original virus material. In Test 2 the three concentrations (1/10, 1/20, 1/100) which were used did not show much difference in their effect, may be for the reason that grown larvae are susceptible to the least concentration of the virus-suspension. In Test 4 the larvae were of the first and second instars, which need, according to the laboratory results, a concentration of the suspension of not less than 25 millions of polyhedral bodies per one millitre. Nevertheless, a highly diluted suspension of 1/500 was used in this test and spraying of the plants' foliage was secured. The result was very successful and the tiny larvae succumbed to the effect of such treatment.

The virus suspension was sprayed on three different crops that were infested with *Prodenia* larvae at different times. The first crop was cotton the plants of which were sprayed with the virus suspension on July 13th and on July 28th. The effect of the first spray was checked only through the first four days after treatment and then the plants were sprayed with a chemical insecticide. This short duration did not give enough chance for the disease to develop. In later tests it was realised that under field conditions death due to the virus disease is not mostly accomplished before the seventh day after spraying the virus suspension.

In Test 2 the effect of the disease was clearly shown on the young larvae by keeping down their population density to a non-economic level in spite of the heavy egg laying and successful hatching. The treated cotton plants did not suffer much damage beyond their condition before the treatment. The first and second instar larvae were able to nipple the lower surface of the leaves before they dwindled. The effect of the disease continued to be virulent for a period of 4 weeks when some of the larvae that were able to reach the fully grown stage caught the infection quite readily and died. Their dead bodies were visibly hanging from or stretched on the top parts of the plants.

In Test 3, on sweet potatoes, the grown *Prodenia* larvae did not succumb to the effect of the disease before the seventh day after spraying. The continuous flow of migrating larvae from the near-by land made it impracticable to estimate the effect of the disease on the larval population density and the damage condition of the foliage.

In Test 4, on alfalfa, the effect of the disease on the larvae of the first and second instars was clearly shown in the field. Many of their tiny dead bodies were found stuck on the top parts of the plants. The residual effect of the affliction continued for a whole month until the alfalfa was chopped. During that period larvae of different instars were continuously succumbing to the effect of the disease. The migrating larvae from surrounding areas prevented proper estimation of the effect on the larval population density.

The facts which can be drawn from the above tests on the effect of the virus disease on *Prodenia* larvae in the field are as follow:

(1) The virus suspension sprayed on the plants in the field carries successfully a fatal infection to *Prodenia* larvae that consume the contaminated parts of the plant.

(2) The original material of the virus, provided that it is properly collected, can be diluted up to 500 times with tap water and the disease can be still virulent against all instars of *Prodenia* larvae.

(3) The disease does not interfere with oviposition or egg hatching. It causes death to a few numbers of the first and second instar larvae, and to a greater number of the third instar larvae. Grown larvae are readily susceptible to the effect of the disease.

(4) The treated plants can be saved, to a great extent, from the ravage of *Prodenia* larvae infestation provided that larval migration from non treated plants can be avoided. Virus-sick larvae consume very little food three days after having been infected and later they hardly touch the food.

(5) The residual effect of the virus disease on the treated plants is unlimited. Since spraying the virus suspension, the liquified bodies of the dead larvae that are usually found on the top parts of the plants cause to contaminate the new growths and so the infection is continuously carried over.

(6) The disintegrated virus-dead larvae are very appealing to the healthy *Prodenia* larvae as well as to other insects that roam about the host plants such as ants, wasps, and flies. Such appeal helps spreading the infection among healthy *Prodenia* larvae but has no effect on other insects.

(7) The smell of the virus treated plot is very distinctive, especially after the disease reaches the epidemic level among the grown larvae. Such smell seems to attract *Prodenia* larvae from the surrounding places as far as 25 metres from the treated plot. This phenomenon causes disturbance to the effect of the disease on the larval population density in the treated plot. Therefore, precaution should be taken to prevent migration of larvae towards the test plot. On the other hand, the control plot should not be so close but lay remote from the test plot.

(8) The results of the test approve the statement of THOMPSON and STEINHAUS (1950) that "The timing of the disease application may be so critical that the average grower may not be in a position to determine when the virus should be used. At the time of application, the caterpillars have not yet begun to cause noticeable damage, and the grower may not even be aware of their presence. Once damage begins to show in the field, it is usually too late to use the virus disease as a practical means of control".

V. SUMMARY

(1) Four tests were conducted in the field to investigate the effect of a polyhedrosis virus disease for the control of *Prodenia litura* F. larvae. The disease was

in the form of diluted suspension which was sprayed on the plants of the test plots.

(2) Great difficulty was experienced through breeding *Prodenia* larvae in the laboratory to infest them with the virus disease. It is suggested to treat a piece of land under clover that is heavily infested with *Prodenia* larvae during May, and so to be able to collect the virus material necessary for the control of the pest on cotton plants.

(3) The first and second test plots were under cotton plants and lay at Tafteesh El-Khazzan in the northern region of the Delta. The third test plot was under sweet potatoes and the fourth test plot was under alfalfa ; both lay in Giza at the farm of the Faculty of Agriculture.

(4) The virus disease caused death to all instars of *Prodenia* larvae in the field, even under the low concentration of 1 part virus material to 500 parts of tap water.

(5) The treated plants were saved, to a certain extent, depending on the time of application, from the ravage of *Prodenia* larvae, but the real effect of the disease on the larval population density was underestimated due to the migration of larvae from untreated areas surrounding the test plots.

VI. ACKNOWLEDGMENT

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ECOLOGICAL STUDIES ON *STOMOXYS CALCITRANS* L. AND *SITIENS* ROND. IN EGYPT, WITH SUGGESTIONS ON THEIR CONTROL

[*Diptera : Muscidae*]

(with 13 Text-Figures and 9 Tables)

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I. INTRODUCTORY AND HISTORICAL

It is hardly necessary to emphasize the importance of blood-sucking flies; their nuisance to live-stock may pale into insignificance if we consider their potentialities as vectors of disease. Unfortunately, in Egypt, these flies, though abundant and probably play an active part in the dissemination of disease, yet, very little attention has been paid to them and our knowledge on their biology, ecology and control are quite inadequate and fragmentary. This state of affairs provided a sufficient incentive to undertake a series of investigations on this group of flies starting with two prominent members, *Stomoxys calcitrans* L. and *sitiens* Rond. The former

species, previously recorded from Egypt by STOREY (1916) and WILLCOCKS (1918), is widely distributed throughout the country including the semi-desert areas and the Nile valley. The latter species, first recorded in Egypt by the present authors, occurs in certain parts, particularly, those cultivated areas lying on the edge of the desert, (Abu Rawash farm, south west of Cairo where it manifests itself in extreme abundance, Gabal Asfar, Abu Zabal quarries and Helwan). *Stomoxys sitiens* (Fig. A) is easily differentiated from *calcitrans* by (1) the presence of elongate more or less

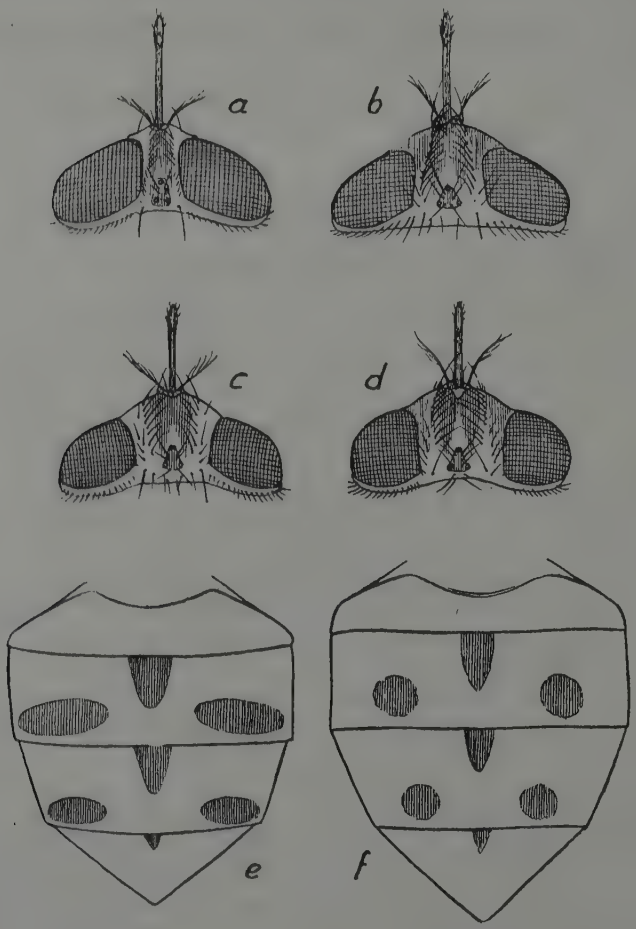

FIG. A: Structural differences between *Stomoxys sitiens* Rond. and *calcitrans* (*a* and *b*, male heads of *sitiens* and *calcitrans*; *c* and *d*, female heads of *sitiens and calcitrans*; *e* and *f*, abdomens of both sexes of *sitiens* and *calcitrans*).

transverse stripes on the abdomen instead of the characteristic rounded spots of *calcitrans*; (2) its general body surface, especially in the orbits, genae, and face is covered with white and shiny pruinosity without any trace of yellowish tint which is characteristic of *calcitrans*; and (3) the inter-ocular space which is narrower than in *calcitrans*, a structural difference which is more obvious in the male.

Both flies form a considerable menace to our cattle and other domestic animals tormenting them severely by their painful bites and possibly transmitting to them a number of virulent diseases.

In other countries, the veterinary and medical importance of the stable fly *F. calcitrans* L. has been emphasized by a number of workers, notably, BRUES and SHEPPARD (1912), SAWYER and HERMS (1913), BRUES (1917 and 1923), HILL (1918), ACTON (1918), ONORATO (1922), PORTER (1924), KNIPLING and RAINWATER (1937) and BISHOPP (1939).

Concerning the biology of *S. calcitrans*, NEWSTEAD (1906), was the first to give an account of the breeding habits of this insect. This author could not find the larvae or pupae in the faeces of domestic animals in farm yards and manure heaps, but he observed oviposition in a heap of fermenting grass mowing. About 4 years later, this insect attracted the attention of PORTSCHINSKY (1910), who gave an account of its biology in relation to that of other coprophagous flies. His work confirmed Newstead's conclusion that *S. calcitrans* does not oviposit in horse or cattle dung in open fields and woods. He found that in towns and around stables, heaps of horse dung form the chief, if not the only breeding places. About three years later, and after the announcement of the severe fly outbreaks in southern Manitoba, South Africa and United States (North Texas), and the resultant losses among animals and livestock, this insect aroused the interest of entomologists, such as MITZMAIN (1913), THOMSEN (1938) and BISHOPP (1913, 1920, and 1939), who gave important accounts of the bionomics of this fly, referring to its local abundance, longevity, oviposition, feeding and breeding habits. But the knowledge about the stable-fly remained rather inadequate until the German entomologist WILHELMI (1917) published his monograph on the stable fly, including its hibernation, state of rest and mobility, behaviour to light and temperature, nourishment, sex ratio, development, enemies, parasites and its local distribution.

Several substances which served as breeding grounds for *S. calcitrans* were reported by different workers. Some workers found that pure cow, buffalo, horse and donkey dung does not attract the fly for oviposition, but mixing the dung with humid straw and urine, rendered it attractive as an ovipositional medium (HINDLE, 1914; THOMSEN and HAMMER, 1936; THOMSON, 1937; EDWARDS, OLDROYD and SMART, 1939; HAFEZ, 1941; and BUSVINE, 1951). On the other hand SURCOUF (1921), PATTON (1931), SEGUY (1933 and 1935), YOKOO and HOTARI (1941) and KANO (1953) recorded that the fly breeds in pure cattle and horse dung. However, most recently, PERRAJU and TIRUMALARAO (1956) in India have found that *S. calcitrans* larvae breed actively on rotting cake manure which was added as fertilizer to melon

crop. The cakes used were containing the residual matter left over after extraction of oil from the seeds of Pungam (*Pengamia glabra* V.) and neem (*Azadirachta indica* A. Juss.) in addition to groundnut (*Arachis hypogea* L.) cake. In their report, they stated: "The stable fly, *Stomoxys calcitrans* L. usually occurs in small numbers all over India, but in the Cuddapah District, it suddenly assumed the status of a serious menace to cattle as a result of an intensive application of cake manure to the melon crop grown on the bed of the Pennar river".

Several methods for rearing the fly in the laboratory have been reported by GLASER (1923), DOTY (1937), CAMPAU, BAKER and MORRISON (1953), and GREGOR and DREISS (1955). The literature also contains valuable notes about the response of the adult to various factors such as temperature, smell, and humidity, notably in the works of KRIJGSMAN (1930) and NIESCHULZ (1933). Scattered observations on the biology of the insect were mentioned by some authors, e.g. BRÈTHES (1919), ACTON (1919), LARSEN and THOMSEN (1940), and LARSEN (1943).

As to *Stomoxys sitiens* Rond., it seems from the review of literature available to the writers that no biological studies on this species were made by previous workers. A short note, however, describing the species as a new record to Egypt and stressing some points about its bionomics, was given by the present authors (HAFEZ and GAMAL-EDDIN, 1957).

II. MATERIAL AND METHODS

For studying the two species of *Stomoxys* in their natural habitat, regular monthly camps and excursions were made in and to Abu Rawash farm. Many other surveys were made in several localities of different provinces of this country. For the determination of the climatic conditions of the farm, two thermo-hygrographs were left; one in the open and the other inside the artificial forest, to record the air temperature and humidity. The amount of evaporation of the air was measured by the Piche Evaporimetre.

To determine the seasonal variation of flies, their sex ratio and breeding season in nature, sweepings for one hour, on the legs of one donkey bait, in a fixed station were made. Every fifteen minutes there was two minutes pause, during which flies resting in the immediate vicinity of the animal were disturbed to settle again on the legs. The arithmatic mean of constant 8 catches was considered as the fly index per month. For the study of the breeding season in nature, the collected females were dissected and the percentage pregnancy among them was calculated. The time of the year at which the majority of dissected females contained mature ovaries was considered as the breeding season. For the determination of the diurnal changes in fly numbers and their sex ratio, the same method used for the determination of the seasonal variation of the flies and their sex ratio was adopted with some modifications. Sweepings were taken from the early morning to the late afternoon,

and sometimes the process began at dawn, but differed with the different seasons. Sweepings for fifteen minutes hourly were made and the average catch of every two hours on two successive days was considered as the fly index per hour. The hourly catches were made in days selected to represent all seasons of the year.

To determine the breeding media of the flies in nature and their local distribution, many localities, in the country, in towns and the desert were frequently visited, mainly in the breeding season and the time of the increased activity of the flies.

A standard culture was raised and maintained in the laboratory. Breeding cages 30 × 30 × 40 cm. were used ; each cage was provided with a pad of cotton wool moderately soaked with warm citrated calf blood and a tray containing an artificial breeding and oviposional medium prepared by mixing one part by volume of wheat bran with one part of berseem (Egyptian clover) meal and about two parts of wood-shavings and moistened with water. When large colonies of flies were required, this medium was replaced by small Petri-dishes, containing fresh horse dung, the highly preferred ovipositing medium for flies in nature. After being deposited, the eggs were transferred into glass jars (8 × 15 cm) and each containing about twenty gm. of clover + bran mixture, then tightly covered with muslin. The adults just after emergence were transferred into breeding cages ; each group of adults emerging in the same day were placed in a separate cage.

The method used for feeding both species of *Stomoxys* in the laboratory was based on feeding them on drawn blood of animals. Feeding directly on alive animals was not practical. This was also emphasized by Glaser (1928), Doty (1937), Campau, Baker and Morrison (1953) and Gregor and Dreiss (1955). However, Mitzmain (1913), stated the reverse; he found that drawn blood of animals did not answer the requirements of the fly, even when renewed daily. He also added that flies nourished in this manner usually did not survive longer than flies kept without food. The latter observation, however, is not in agreement with the results obtained by the present authors on longevity experiments, since flies bred on drawn blood lived much longer than starved ones. The procedure used by the present authors for feeding the adults was similar to that of Doty (1937), with some modifications about the percentage of the chemicals added to the blood and the time required for refrigeration. The blood was received from freshly slaughtered buffalo calves, in sterilized bottles of capacity 1000 cc. Each bottle contained 100 cc. of sterilized 3% sodium citrate solution to prevent coagulation. The bottles were not fully filled with blood to allow for immediate vigorous shaking which was very necessary. This citrated calf blood was then placed in a refrigerator as soon as possible. Blood prepared by this method appeared to have no harmful effects on the flies or the progeny, and could be kept effective for about one week. The flies were fed twice daily ; early in the morning and late afternoon, on citrated calf blood, taken fresh from the stock in the refrigerator. The blood was first transferred into small sample tubes 10 × 2.5 cm. and dipped in warm water (not in boiled water), to raise

the temperature of the blood up to about 30 C., which was found attractive for the flies for feeding. The warm blood was then poured into small Petri dishes. Pieces of cotton wool surrounded by muslin cloth were dipped inside the Petri dishes and once soaked with blood, were immediately introduced into the cages containing flies. It may be pointed out that repeated trials to feed *Stomoxys* on cold blood was invain, therefore, especially during the winter, care was taken to introduce the warmed blood immediately into the cage for feeding flies, otherwise, it became cold and persistently refused by the flies.

For the determination of the longevity of the flies, each newly emerged one was placed in 3 × 10 cm. specimen tube together with a piece of cotton wool soaked in the food, and covered with muslin.

The ecological and biological studies carried out in the course of the present work continued for about three years.

III. THE NORMAL ENVIRONMENT OF *STOMOXYS*

A. Locality

A greater part of this work has been carried out at Abu Rawash farm, lying on the edge of the desert, west of Cairo, and about twenty kilometres north west of the great pyramid of Giza.

The general topography of this locality is characteristically flat for the most part and can be naturally distinguished into the following five regions:

(1) A northern part, comprising an extensive area of swamps extending for about two kilometres.

(2) A southern part, bordered by the Cairo-Alexandria desert road.

(3) An eastern part, which is an extensive cultivated area.

(4) A central part, embracing an artificial forest and large basins for sewage disposal.

(5) A western part, comprising the buildings of farm labourers.

Most of the field studies of the present work were mainly carried out in the artificial forest and the neighbouring places where larvae and flies of both species of *Stomoxys* were encountered in prodigious numbers.

The vegetation in this locality may be generally classifled into (1) an artificial forest, (2) grass land, (3) aquatic plants, and (4) cultivated plants; most of these are tomatoes in winter and watermelon and barley in summer. In the artificial forest the following plants occur: *Casuarina equesitifolia* (Casuarinaceae), *Eucalyptus globulus* (Myrtaceae), *Dalbergia sisso* (Leguminoseae) *Morus, alba* (Moraceae), *Citrus aurantium* (Rutaceae) and *Opuntia ficus-indica* (Cactaceae).

An outstanding characteristic of this locality is the abundance of the grazing animals, which form a continuous source of food for the flies. Such animals

include donkeys, horses, camels, buffaloes, cows, sheep and goats, in addition to foxes and wolves. Wild ducks, lizzards and snakes are of common occurrence, so are flies of different species, beetles, grasshoppers and aphids.

B. Climatic conditions

The climatic factors including temperature, humidity, evaporation and rain prevailing in the normal environment of *Stomoxys* at Abu Rawash farm (inside and outside the artificial forest) were studied throughout the years 1955 and 1956 and comparisons between the macro-and micro-climatic conditions were frequently made.

1. Air temperature

Table I shows a comparison between the temperatures recorded in the farm during the months of camping and those of the nearest observatory (Imbaba Aerodrome Observatory). Both our records and those of the observatory were usually in agreement, few discrepancies, however, occurred occasionally. For example on hot days, the shade temperature in the farm, if not equal, is slightly lower

TABLE I

Minima, maxima and daily mean temperature in °C. in the farm, during the days of camping as compared with those of Imbaba Aerodrome Observatory.

Date	Farm	Observatory	Farm	Observatory	Farm	Observatory
11. 6.56	35.9	36.2	16.9	17.7	27.0	27.6
11. 7.56	34.0	34.8	18.8	19.9	26.0	27.0
11. 8.56	40.0	38.5	22.0	22.9	30.4	30.5
10. 9.56	34.0	33.0	20.0	20.6	26.3	26.1
9.10.56	30.0	30.8	15.4	17.0	22.5	22.3
20.11.56	32.5	31.6	11.5	13.0	20.7	21.5
11.12.56	14.1	14.4	4.0	3.1	9.1	9.5

than the observatory, but after mid-night the temperature of the farm is slightly higher than the observatory. On cold days, on the other hand, the farm retains a temperature somewhat higher than the observatory during the day and somewhat lower during the night. As to the seasonal variation in air temperature, it is noticed that it has a wide range. Thus the lowest temperature recorded was 1.2°C., in January 1955, and the highest was 41.6°C. in July of the same year. It is thus clear that over the whole year, air temperature varied between cold weather, near the freezing point to very hot weather. In Figure 1, the curve of air temperature shows clearly the seasonal variation. Other than the wide range of air temperature to which the insects are subjected, the flies are also exposed to wide diurnal variations both inside and outside the forest.

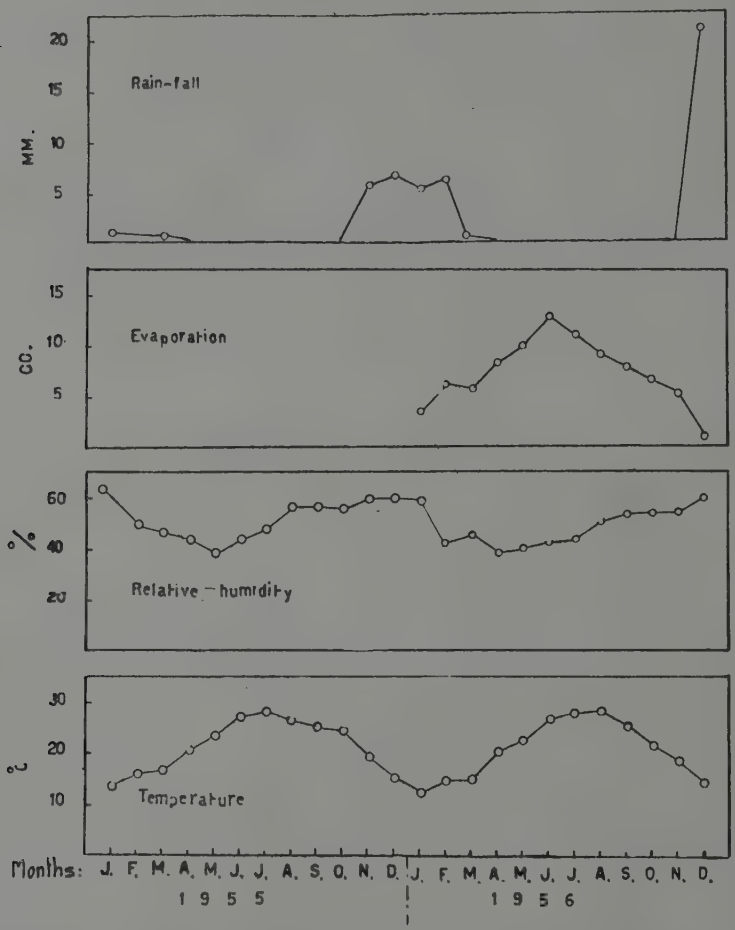

FIG. 1: Seasonal fluctuations in the different climatic factors during the years 1955 and 1956 (Data obtained from the Meteorogical Section at Imbaba Aerodrome).

Fig. 2 shows a comparison between the two records (inside and outside the forest). From this histogram, it is markedly observed that in summer months, when the temperature of the farm is high, the temperature of the artificial forest becomes lower and in winter the temperature of the forest is always higher than the outer atmosphere.

2. Humidity

The relative humidity reached a minimum of 7 and 2% in April 1955 and 1956, respectively. On the other hand, it reached its maximum in February and December 1955 and January 1956, being 98 and 96%, respectively. Thus the locality is at time subjected to as low relative humidity as 2% R. H., which is very dry. In Figure 1, the third curve from upward to downward, shows the seasonal fluctuation in the average relative humidity during the years 1955 and 1956. In addition

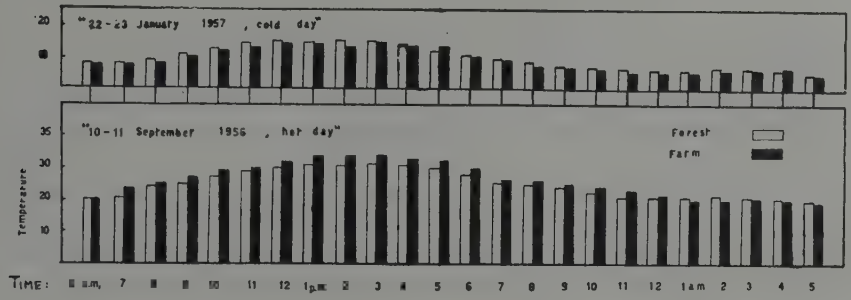

FIG. 2: A histogram showing the hourly change of temperature inside and outside the artificial forests.

to seasonal variations in relative humidity, the flies are subjected also to high diurnal fluctuations. For example, on a hot day, e.g. 11-12 July 1955, the maxima of relative humidities (100%) were usually attained in the late night, from 12 (mid-night) to 5 a.m. of the second day, and the minima (40%) at about 2 p.m. On a cold day, e.g. 21-22 January 1957, the maximum of relative humidity (100%) began from 8 p.m. and this extended to 8 a.m. of the following day; while the minima (52% R.H.) occurred at about 4 p.m.

3. Evaporation

In summer months because of high temperature and low relative humidity, the evaporating power is higher. Thus, during the year 1956, the maximum amount of evaporation was 20.2cc. per day in June, when the air temperature reached a maximum of 41.5°C. On the other hand, the minimum was 1.4 cc./day, in January at an air temperature of 2.3°C. Comparing the evaporating power of the air on a relatively hot day with that on a cold day, we find that in both cases, the flies are subjected to high evaporating power at relatively high temperature and low relative humidity. For instance, on 9.7.56 (hot day), evaporation reached a maximum of 13 mm./h. at about 4 p.m. and a minimum of 1 mm./h. from 12 mid-night to 6 a.m., while on 22.1.1957 (cold day), these figures were of 5 mm./h. at 3 p.m. and 0.5 mm./h. at 7 a.m. respectively.

4. Rain

It can be generally said that the locality under investigation is subjected to a long period of complete drought. Even in the rainy season, the number of rainy days is very limited and the total rain-fall does not exceed few millimetres. For example, during the year 1955, the rain fell on 11 days in January, March, November and December and the total amount of rain-fall was 16.6 mm., while during 1956, it fell on 18 days and the total amount of rain-fall was more i.e. 36.3 mm.

IV. HABITS OF THE ADULT

Stomoxys calcitrans and *sitiens* are day-time unsedentary ectoparasites of homoio-thermic domestic animals. They are typically out-door insects, commonly met with in the open, the latter, however, prefers the cultivated semi-arid localities especially those lying on the edge of the desert. At Abu Rawash and Gabal Asfar farms, where these flies abundantly occur, it has been always noticed that at extreme midday temperatures during the hot season of the year, the flies seek shelter in the neighbouring artificial forest and other shaded situations. Also in the country, the same phenomenon takes place, *S. calcitrans* always retiring during excessive heat to open stables and sheds. While camping one spring in Abu Rawash farm, the authors pitched their tent near an artificial forest, which served as the breeding,

TABLE II

Time of appearance of Stomoxys *at Abu Rawash farm, compared with temperature and sun-rise.*

Date	Time of appearance		Temperature in °C. at time of appearance				Time of sun-rise(*)
			Sun		Shade		
	calcitrans	*sitiens*	*calcitrans*	*sitiens*	*calcitrans*	*sitiens*	
11. 6.56	6 a.m.	4.30	26.0	—	22.0	20.5	4.53
12. 6.56	,,	,,	,,	—	22.0	20.0	,,
11. 7.56	5 a.m.	4.50	—	—	20.0	20.0	5.2
12. 7.56	,,	4.40	—	—	,,	,,	,,
10. 8.58	7 a.m.	4.55	27.5	—	26.0	24.0	5.19
10. 9.56	7 ,,	5.20	25.0	—	23.5	20.0	5.37
10.10.56	8 ,,	6.25	24.5	17.0	20.0	15.5	6.53
20.11.56	8 ,,	7.00	25.5	19.2	23.5	16.5	6.23
11.12.56	9.30	9.40	16.6	16.5	12.0	13.0	6.40
22. 1.57	11.0	9.00	16.5	14.0	13.0	10.5	6.51
17. 2.57	7.55	8.15	12.0	13.5	9	11.0	6.34

*At Almaza, as shown by the Climate Section, Ministry of War.

resting and feeding grounds for *Stomoxys*. Every noon, the flies would come into the tent biting severely and resting on the walls and roofs. As the temperature of the outer atmosphere drops, the flies leave the tent and swarm on the animals, resting or grazing in the open. It seems therefore, that the occurrence of the flies around stables, byres or houses is only for protective purposes, and for short periods until favourable temperature conditions set in again. The term stable fly as BISHOPP (1939), pointed out is not entirely an appropriate designation, as the fly spends most of its time in the open and hardly in the stables.

The beginning of the fly activity in the field has been studied all the year round. For this purpose, a donkey was used as a bait for the flies and was tied near the artificial forest, the resting grounds for *Stomoxys*. The results obtained are included in Table II, from which it is clear that during the warm season (June-September), *S. sitiens* appears on the animal before sun-rise, while *S. calcitrans* appears later, usually after sun-rise. In autumn and winter months, on the other hand, both species appear after sun-rise, however *S. sitiens* appears earlier as shown in Table II.

MITZMAIN (1913), has stated that in April, the greatest infestation by *S. calcitrans* was the hour preceding 6.30 a.m.

It has been found that the lower temperature at which *S. calcitrans* appears in the open is 12°C. in the sun. WILHELMI (1917), in Germany, pointed out that the flies were active in the open at 12°C., and stopped being so at 11°C. and below 10°C., those found in the open were thrown into a state of stupor. As to *S. sitiens*, the fly usually appears at lower temperatures than those of *S. calcitrans* (Table II).

The flies activity in the sun is a thermotropic response rather than a phototropic one. This was demonstrated by repeatedly recording the behaviour of the flies settling on a donkey in the open. It was found (Table III) that during the hot months, both species were active in the open in the sun-lighted side of the animal at temperatures up to 30°C., but at higher temperatures they sought the shaded side of the animal, or migrated to the neighbouring artificial forest. In cold months, when temperature did not usually exceed 25°C., in the sun, the fly always preferred the sun-lighted side of the animal. It was also noticed that a burst of sun-shine on a cloudy day would increase the number of flies caught, and the appearance of clouds in sunny winter day will decrease the number. This observation may explain why under conditions prevailing in Abu Rawash farm, *S. calcitrans* and *sitiens* were active during the hot months, in the open, all the day long except for a short period at midday. On the other hand, in cold months, the period of maximum activity occurs in midday.

It was often said by the majority of workers, that *S. calcitrans* is positively helio-tropic insect. In the light of the above results, it seems that under conditions prevailing in this country, this is not always the case, as the fly was negatively heliotropic in hot months and positively so in the cold season.

TABLE III

Number of S. calcitrans *and* sitiens *caught at various hours of the day, on a donkey bait and their behaviour towards the sun.*

11 August 1956 (hot day)

Time	Number of *calcitr-ans*	Number of *sitiens*	Sun temp. in °C.	Shade temp. in °C	Preferred sun-lighted side		Preferred shaded side	
					calcitrans	*sitiens*	*calcitrans*	*sitiens*
7 a.m.	7	1752	27.0	26.0	Yes	Yes	No.	No.
8 a.m.	4	249	30.0	29.0	Yes	Yes	No.	No.
9 a.m.	2	251	34.5	32.0	No.	No.	Yes	Yes
10 a.m.	5	16	35.0	34.5	,,	,,	,,	,,
11 a.m.	2	4	37.0	36.0	,,	,,	,,	,,
12 a.m.	0	2	38.5	38.0	Absent	No.	Absent	Yes
1 p.m.	0	1	39.5	39.0	Absent	,,	,,	,,
2 p.m.	0	1	40.0	40.0	Absent	,,	,,	,,
3 p.m.	0	2	41.0	40.0	,,	,,	,,	,,
4 p.m.	0	1	39.5	38.5	,,	,,	,,	,,
5 p.m.	4	23	37.0	36.0	No.	,,	Yes	,,

17 February 1956 (cold day)

7 a.m.	0	0	10.5	9.0	Absent	Absent	Absent	Absent
8 a.m.	1	0	13.3	9.5	Yes	,,	No.	,,
9 a.m.	1	2	17.5	13.0	,,	Yes	,,	No.
10 a.m.	14	29	18.5	17.0	,,	,,	,,	,,
11 a.m.	33	89	20.2	19.0	,,	,,	,,	,,
12 a.m.	22	89	21.0	19.0	,,	,,	,,	,,
1 p.m.	36	120	23.3	19.5	,,	,,	,,	,,
2 p.m.	29	286	24.5	21.0	,,	,,	,,	,,
3 p.m.	28	203	24.5	22.0	,,	,,	,,	,,
4 p.m.	18	199	20.5	21.5	,,	,,	,,	,,

V. BREEDING SEASON IN NATURE

The time of the year at which the majority of the females contained mature ovaries was considered as the breeding season in nature. This method was adopted by BUXTON (1955) to show the breeding season of *Glossina*. This procedure is more appropriate and accurate than recording the relative abundance of larvae and puparia in the breeding medium. The data obtained are illustrated in Fig. 3, from which it is clear that the rate of breeding of *S. calcitrans* is markedly low in winter mainly in January, but rises gradually in the spring reaching its maximum in May after which an obvious fall takes place during late summer and autumn, but rises

slightly in October. In May, the peak was reached when 99.3% of the flies were pregnant. In *S. sitiens*, the peak occurred a month later, in June, when the pregnancy was 100%. Like *calcitrans*, the lowest pregnancy was recorded in January and

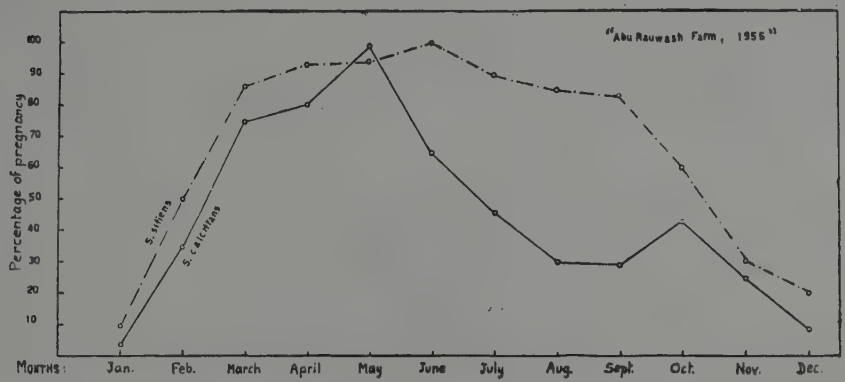

FIG. 3: Seasonal incidence of pregnancy among the females.

December. But it should be pointed out that the breed ng season of *S. sitiens* extends over a much longer period, practically, from March till September, when a distinctly high percentage of pregnancy (minimum 83%) is manifested throughout.

VI. BREEDING MEDIA

Extensive field observations and laboratory experiments were carried out to study the chief breeding media and foci for *S. calcitrans* and *sitiens* under conditions prevailing in Egypt. The field observations were conducted (a) in the country, mainly in lower Egypt, at Bahada (January 1955), Darawah (April 1955), Gabal Asfar (June 1956), Kalioub and Sanafir (June 1956); (b) in the region of Cairo, at the following localities: Darrasa (February 1956), Ard El-Naam (April 1956), Zawia Hamra (May and June 1956) and Dir El-Malak (July 1956); and (c) at Abu Rawash farm on the edge of the desert.

A. Results of observations in the field

Results of observations in *the country*, seem to indicate that, in cold season, the females of *Stomoxys calcitrans* leave the outer breeding grounds and seek shelter inside byres and stables, where they also oviposit in the animal beddings formed of dung, straw, food remains, fodder and urine. The temperature of this mixture varies from 22 to 28°C. In warm seasons, on the other hand, the females breed chiefly in the open in the shaded spots, preferring cattle and horse dung when

mixed with straw and urine, where the temperature is generally between 22 and 28°C. Repeated observations have revealed that pure cow, buffalo, donkey and horse dung does not attract both species for oviposition. Therefore, it seems that mixing with humid straw and urine is essential for rendering these kinds of dungs attractive as ovipositional media. A similar finding was recorded by HINDLE (1914), BISHOPP (1913, 1920, and 1939), THOMSEN and HAMMER (1941), EDWARDS, OLDROYD and SMART (1939), HAFEZ (1941), and BUSVINE (1951). While NEWSTEAD (1906), MITZMAIN (1913), WILHELMI (1917), SURCOUF (1921 and 1923), PATTON (1931), SÉGUY (1933), YOKOO and HOTARI (1941), and KANO (1953) recorded that *S. calcitrans* breeds in pure cattle and horse dung. *S. calcitrans* breeds also in camel dung mixed with straw and wetted with urine, but this dung is far inferior in its attractivity as compared to that of cattle, donkey and horse dung. While, sheep, goat, fowl and rabbit dung, on the other hand does not attract the flies for oviposition.

In the *region of Cairo* and the neighbouring districts, it has been found that horse manure mixed with straw and wetted with urine, affords the preferred breeding medium for *S. calcitrans*. In large and tightly packed heaps of this manure exposed in the open, larvae or pupae are usually not found, mostly due to the strong

FIG. 4: Breeding spot of *Stomoxys*
(decaying plant leaves under which great numbers of *Stomoxys* larvae were found).

fermentation which takes place, and the relatively high temperature (up to 60°C.) generated in these heaps. Another breeding medium, which in our belief, plays an important part in the fly production of *S. calcitrans* in Cairo districts is the mixture of straw, lawn cuttings and decaying vegetable materials which are usually left on

the banks of water canals. As regards pig dung, it has been found that it is unattractive for *Stomoxys* for oviposition. Repeated investigations have definitely shown, that *Stomoxys* as a rule, never breeds in human excrement and does not frequent the cesspits of privy middens or similar places, which are frequently visited by the house-fly.

In Abu Rawash farm and other similar localities lying at the edge of the desert, such as Gabal Asfar and Darawah, *S. sitiens* and *calcitrans* are of frequent occurrence, and their breeding grounds are numerous. In Abu Rawash farm, the

FIG. 5: Breeding ground of *Stomoxys* at the base of an *Eucalyptus* tree.

larvae as well as the adults manifest themselves in extreme abundance and outnumber all other blood-sucking flies in all seasons of the year. In this locality, the two species are entirely out-of-door insects. In cool months, the flies prefer the sunny beddings below the animals (cow, buffalo, donkey and horse) which consist of barley straw, weeds, lawn cuttings and other vegetable remains which are frequently mixed with dung. In the warm season, on the other hand, the flies breed extremely in the shady artificial forest. The larvae of both species occur abundantly among the decaying leaves fallen in the soggy soil (Fig. 4), where high moisture and moderate

temperature (22-28°C.) prevail. It is important to refer here, that larvae of both species were occasionally encountered in a mixture of sand and vegetable debris lying at the base of a large *Eucalyptus* tree. This mixture was rendered moist by the organic juice dropping from an injured part of the tree trunk (Fig. 5). A similar observation was recorded below a fallen *Eucalyptus* trunk (Fig. 6).

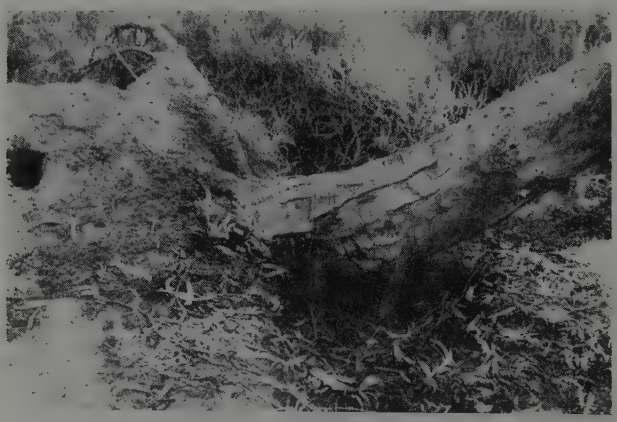

FIG. 6: Fallen trunk of an *Eucalyptus* tree (larvae of *Stomoxys calcitrans* and *sitiens* were occasionally encountered in the moist sand mixed with decaying leaves below the trunk).

From the foregoing results, it is noticed that, in the country, *S. sitiens* is entirely absent; *calcitrans* only encountered but in relatively less abundance than in Abu Rawash farm. In winter and under conditions prevailing in the country, the fly (*calcitrans*) is rare in the open, but occurs in smaller numbers inside stables and byres where they apparently seek shelter and also oviposit. During the warm season, on the other hand, the breeding media become available in the open and the flies start ovipositing, preferring shaded situations. In such open areas, as Abu Rawash farm, where the breeding grounds are always available and exposed in the open, the flies choose their breeding sites in sunny situations during the cold months of the year, and shaded ones in the warm season. In both cases, however, the insect seems to have a definite thermo-preferendum within which it performs these processes. THOMSEN and HAMMER (1936), have stated that in warmer climate, *S. calcitrans* lives to a greater extent in the open. HAFEZ (1941), on the other hand, stated that *S. calcitrans* oviposits in the open as well as inside the stable, but more extensively in the latter case.

It may also be pointed out that the breeding medium of both species of *Stomoxys*, must fulfill certain requirements; it must be loose and porous, with

high moisture content and moderate temperature, and preferably located in shaded situations during the warm season. Also the breeding ground must be in the immediate vicinity of the suitable feeding grounds, as oviposition is usually preceded by blood meals.

B. Oviposition experiments

The above mentioned results clearly revealed that *S. calcitrans* and *S. sitiens* flies, in Egypt, prefer certain kinds of breeding media for oviposition. In order to test the power of attraction of the different kinds of breeding media for the ovipositing females and to what extent external and internal factors may be involved, some experiments have been conducted, during which the flies were given the option of six kinds of animal dung (donkey, horse, buffalo, cow, sheep + goat and camel dung) and two other artificial breeding media (cooked rice straw and cooked plant leaves soaked with donkey urine). Series of experiments were made in the years 1955 and 1956 during the flies breeding season (May and June); two at Gabal Asfar farm and a third at Abu Rawash farm. In the former locality, eight vessels containing the above mentioned materials were placed in a large donkey and horse stable and were left from 12 noon to 3 p.m., the time at which the flies usually resort to the stable for shelter, and other eight vessels were placed in the open, from 4 a.m. to 7. a.m., in the neighbourhood of the feeding sites of the flies. The dung used was taken fresh from the animals, but not sterilized by heating in order to avoid any possible change in its properties. This procedure does not guarantee with absolute certainty that the dung used might not have contained eggs at the commencement of the experiment (as this was the case in some vessels). There was, however, no reason to believe that this method had any considerable influence on the final results of experiments. This was also emphasized by THOMSEN and HAMMER (1936) and HAFEZ (1941).

In the region of Abu Rawash farm, eight other vessels containing the above mentioned materials were placed near the artificial forest (the breeding and resting grounds for the flies). They were left from 4 a.m. to 7. a.m. (the time of the increased activities of the flies in the open). In both Gabal Asfar and Abu Rawash farms, after the vessels had been exposed for egg-laying, they were taken to the laboratory where they were covered with muslin cloth. When the flies emerged they were collected and counted.

Generally the results obtained from the experiments showed general agreement with those obtained from direct observations. The experiments have shown that the different kinds of breeding media attracted the females in varying degrees. Both in Gabal Asfar and Abu Rawash farms, it seems that cooked rice straw soaked with urine and cooked plant leaves were highly preferred ovipositing media and usually yielded large number of flies. Next in preference, though distinctly inferior, was horse dung then donkey dung. The buffalo, cow and camel dung attracted the ovipositing females to a slight degree. Sheep + goat dung was the least favoured one.

It may be also pointed out that it was noticed that emerging *S. sitiens* flies manifested themselves in extreme abundance and outnumbered the other species *S. calcitrans*. For instance, number of flies of *S. sitiens* and *calcitrans* emerging from horse dung (Gabal Asfar oviposition experiments, in the open) was 973 and 205, respectively. The corresponding figures from cooked plant leaves were 2827 and 593. The latter species (*calcitrans*) emerged from the indoor vessels as well as from those in the open but to a much greater extent in the latter case.

VII. DIURNAL RHYTHM AND SEASONAL VARIATIONS OF *S. CALCITRANS* AND *SITIENS*

A. Diurnal rhythm

To determine the diurnal population changes, sweepings for fifteen minutes hourly were made on the legs of one donkey-bait and the average catch of every two hours on two successive days was considered as the fly index per hour. The hourly catches were made on days selected to represent nearly all the seasons. The hours of the day during which the highest counts occurred and the period of maximum catches were both estimated from the hourly fly index curves (Figs. 7-10). Where obvious peaks occurred, the single hour and temperature were recorded as the time of highest catch. Where there were high levels at several hours, the average temperature of higher points were considered as the temperature of the highest catches.

At outside locations at Abu Rawash farm, maximum fly catches of *S. sitiens* occured between about 22 and 29°C., while those of *calcitrans* occured between about 22.5 and 30.5°C., although maximum temperatures ranged from 24.5 to 40°C. (Table IV). On six days from December to February (cold months). When

TABLE IV

Temperatures during maximum fly catches, compared with the maximum temperatures of the day.

Date	Average temperature during period of maximum catches °C.		Maximum temperature in °C.
	calcitrans	*sitiens*	
11 June, 1956	29.3	26.0	34.5
11 July, 1956	27.5	23.7	34.5
11 August, 1956	30.3	28.8	40.0
11 Septembre, 1956	30.0	24.8	34.0
10 October, 1956	27.4	22.0	30.0
11 November, 1956	28.8	25.0	33.0
11 December, 1956	15.0	15.0	15.0
22 January, 1957	14.0	14.5	15.0
17 February, 1957	19.3	22.0	22.0
24 March, 1957	22.5	22.0	24.5

maximum temperatures were below 22°C., the highest fly catches of *S. sitiens* were found close to the maximum temperature reached, while those of *calcitrans* were close or within two degrees.

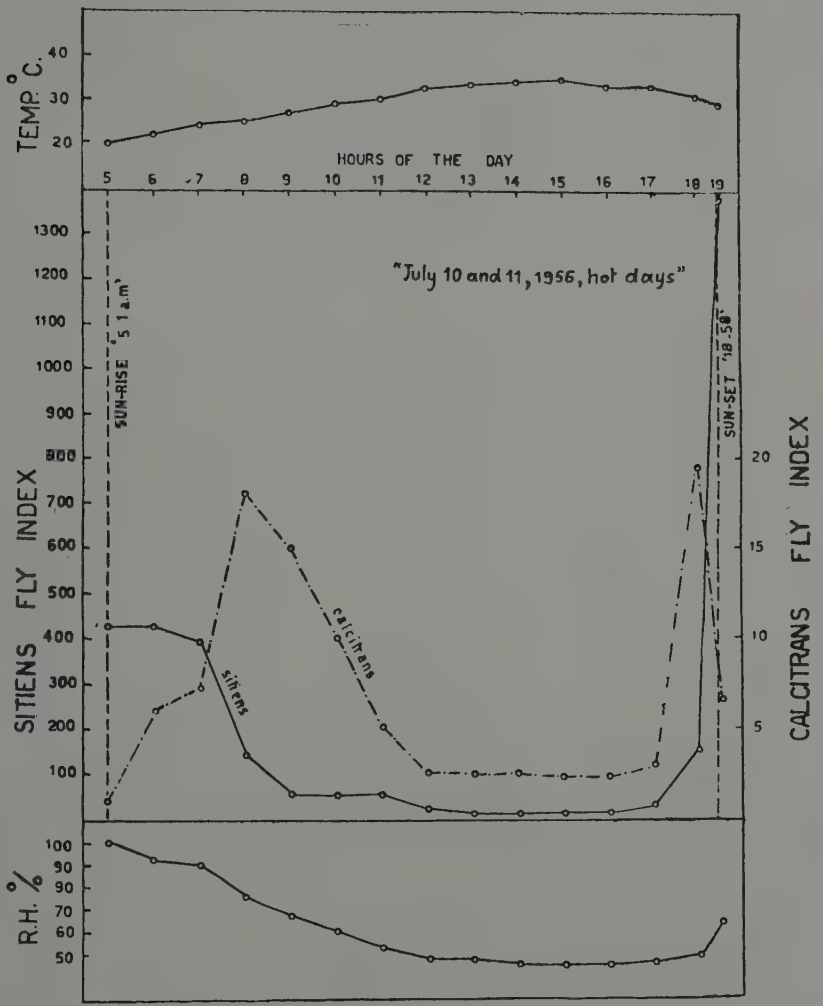

FIG. 7: Hourly fly catches at Abu Rawash farm.

Flies of both species might be moving to cooler shaded parts of the locality when the catches were taken at temperatures above 30°C., and to warmer areas in the cold season. This was demonstrated by recording fly activity on two animals

that served as baits; one inside the forest and one outside. In the former case, the activity of flies was much higher than the latter, the flies apparently seeking the more favourable temperature of the shade. A study of the daily graphs (Figs. 7-10), shows

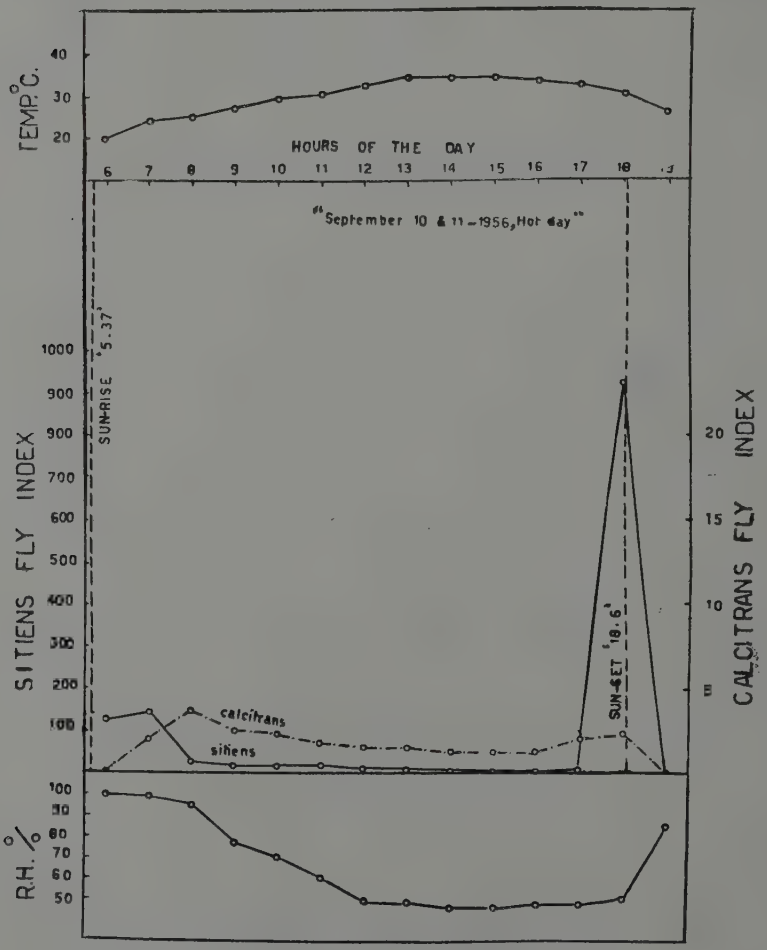

FIG. 8: Hourly fly catches at Abu Rawash farm.

that in hot months, as the temperature rises up from 20 to 30°C., an increase in the number of flies is clearly seen. In other words, it would appear as the outside temperature rises above 30°C., the flies tend to move to shaded trees in increasing num-

bers. For example, on 10 June 1956, *sitiens* flies appeared at about 5 a.m., while those of *calcitrans* appeared one hour later, then the numbers of flies increased gradually and the peaks were reached in the former and the latter species at about

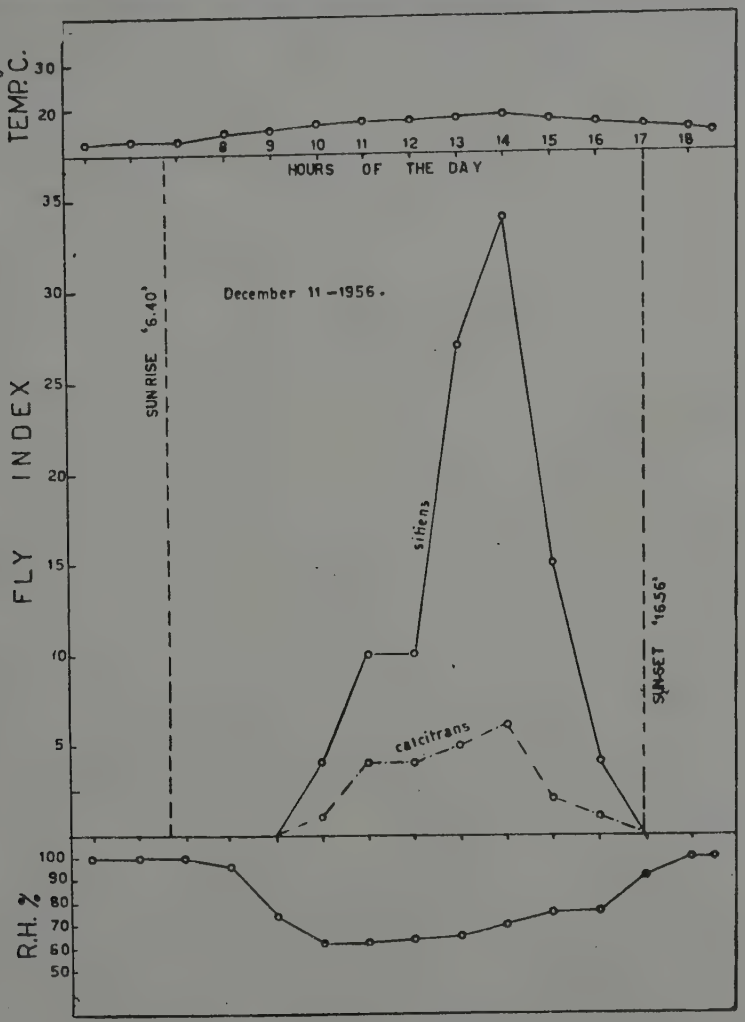

FIG. 9: Hourly fly catches at Abu Rawash farm.

8 a.m. and 11 a.m., respectively. After these morning peaks, the numbers of both species dropped gradually reaching their minima at 1 p.m., when the flies practically disappeared until about 6 p.m., by which time the flies appeared again increasing

rapidly in number and attaining a second peak an hour later at 7 p.m. This latter sunset peak, in mostly all cases, was distinctly higher than the morning peak and also than the corresponding peak of *calcitrans*. In colder weather, for instance, on 11.12.56, the flies appeared in small numbers from 9 to 11 a.m., after which they increased steadily reaching their maximum at 2 p.m.; after 2 p.m., a rapid fall took place (Fig. 9) and disappeared again in about three hours. In February, (Fig. 10),

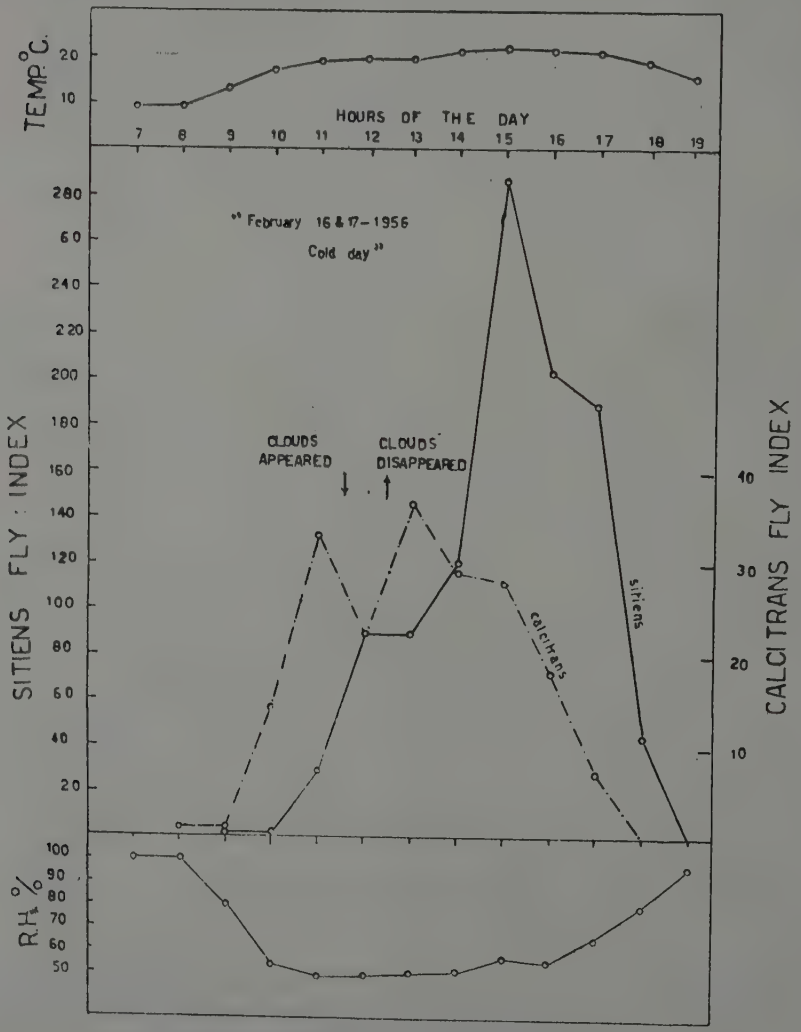

FIG. 10: Hourly fly catches at Abu Rawash farm.

a similar result was obtained but the number of flies dropped from about 11 a.m. to about 1 p.m. (the period of maximum fly activity) as a result of the appearance of clouds in that sunny winter day. In hot season, on the other hand, the presence of two peaks of activities was remarkable constant feature of the fly diurnal rhythm; one early in the morning and one late in the afternoon.

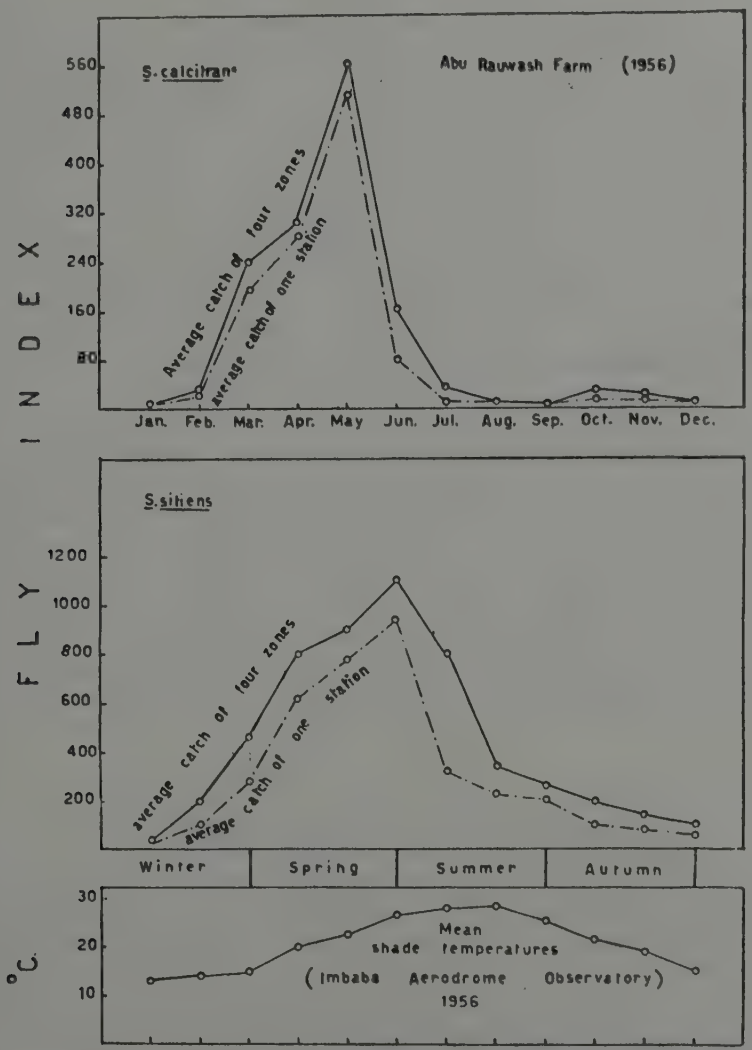

FIG. 11: Seasonal variations in *Stomoxys* fly abundance at Abu Rawash farm (N.B.: In the lower curve, temperatures at Imbaba Observatory and Abu Rawash farm are practically the same).

Observations on night time resting places in the hot season, showed that great numbers of flies clustered on tree leaves, sticks and grasses. These congregations were noticed especially after sunset. Using strong flash lamp light among the trees and grasses caused the flies to be attracted to the light but soon settled again when the source of light was removed.

B. Seasonal variations

To determine the seasonal variations in the number of flies, sweepings on the legs of one donkey bait in a fixed station, for one hour were made. Every fifteen minutes, there was two minutes pause, during which flies resting in the immediate vicinity of animals were disturbed to settle again on the legs. The arithmatic mean of constant 8 catches was considered as the fly index per month. In addition to the fixed station, four other zones were set up in the locality and the catch for each zone was taken from the different animals, and the arithmatic mean of the catches of the four zones was considered as the fly catch per time, and the arithmatic mean of eight times was considered as the fly index per month. The catches were made at approximately the periods of maximum activity (from 11-14 during December-March and from 6-10 during the other months).

The studies conducted throughout the years (1955-1956) in the region of Abu Rawash farm, have clearly demonstrated that both *S. calcitrans* and *S. sitiens* unlike house-flies have each one annual peak of seasonal abundance, being May and June respectively (Fig. 11). In January, the number of *S. sitiens* flies decreases considerably but rises again gradually in the spring reaching its maximum in June, after which an obvious fall takes place during the late summer and autumn (HAFEZ and GAMAL-EDDIN, the present authors, 1957). *S. calcitrans* flies as compared to *sitiens* show themselves in smaller numbers in all seasons of the year. However, in January, the number decreases considerably but increases gradually in the spring reaching its maximum in May after which an obvious fall takes place, but the curve rises slightly in October, after which it falls again.

VIII. LONGEVITY

A. Longevity under room conditions

The longevity of both sexes differed according to seasons, thus during the cold season, from December to January (17-19°C.), the average longevity of the female was about 412.7 hours and that of the male was about 621.2 hours (Table V). In the spring, on the other hand, e.g. in April (20-26.5°C.), the longevity of both sexes was distinctly shorter, the female lived for an average period of about 149 hours, while the male for about 402 hours. It is noticed from these results that the male is more long-lived than the female and that both sexes, under room conditions live much longer in winter than in spring.

TABLE V

The longevity of S. calcitrans *under room conditions*

		April (1956)		Dec. (1956) - Jan. (1957)	
		Male	*Female*	*Male*	*Female*
Length	Min.	113	353	456	550
of adult life	Max.	185	252	648	840
in hours	Aver.	149	402	412.7	621.2
Average of both sexes....		321		541.5	

B. Longevity under controlled conditions

1. Effect of temperature

To test the possible effect of temperature on the longevity of the adults *S. calcitrans*, newly emerged flies were taken from a stock of pupae kept at 30°C. and 90% R.H. Each fly was placed in 3×10 cm. specimen tube together with a piece of cotton wool soaked in citrated calf blood (each 1000 cc. of blood contained 100 cc. of 3% sodium citrate solution) and placed at the bottom. The food was introduced daily, early in the morning and late in the afternoon. The different temperatures used were 25, 30 and 34°C. Records were taken on the length of life of both sexes, the results are shown in Table VI, from which it is clear that the average longevities of the male (362, 264 and 77 hours at 25, 30 and 34°C.) are longer than those of the females (172, 120 and 54 hours). The same phenomenon was recorded by MITZMAIN (1913) and SÉGUY (1935). The difference between the longevities of both sexes decreased with the increase of temperature, being 190, 144 and 23 at 25, 30 and 34°C., respectively; the decrease was rather gradual from 25 to 30°C. and very considerable and abrupt from 30 to 34°C. At 25°C., adults of both sexes lived much longer than high temperature (34°C), thus the longevity increasing with the rise of temperature (Table VI).

TABLE VI

Effect of temperature on the longevity of S. calcitrans

Temperature in °C.	Longevity of the life in hours						Difference between average longevities of both sexes
	Male			Female			
	Min.	*Max.*	*Average*	*Min.*	*Max.*	*Average*	
25	222	504	362	161	185	172	190
30	144	336	264	96	144	120	144
34	48	96	77	36	72	54	23

2. *Effect of food*

The effect of different foods on the longevity of the adult *S. calcitrans* has been demonstrated by BISHOPP (1913, '21, '31 and '39) and YOKOO and HOTARI (1941) and have shown that the average length of life is prolonged when provided with water-sugar solution or blood as compared with those receiving no food.

In order to determine whether or not the presence of different foods may influence the survival of the flies, four series of experiments were conducted. In the first series, distilled water was used as food, in the second, sugar syrup 10%, in the third citrated calf blood (each 1000 cc. of blood contains 100 cc. of 3% sodium citrate) and in the fourth series no food was offered. All these were kept at 25°C., similar ones were carried at 30°C., and 34°C. The results represented in Figure 12, showed that flies receiving sugar syrup lived much longer than those

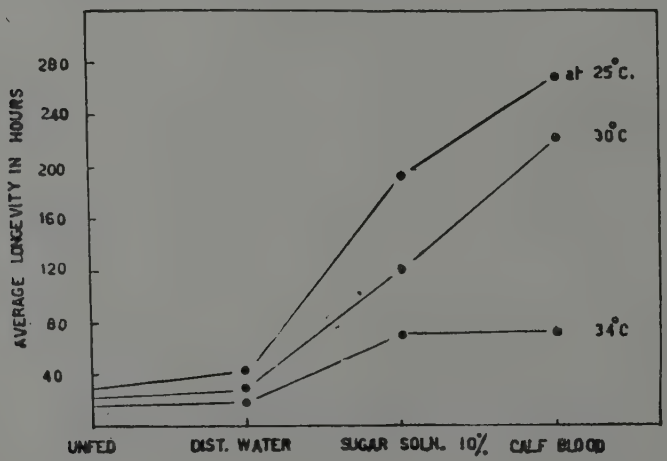

FIG. 12: Longevity of *Stomoxys calcitrans* flies given different foods, at 25, 30 and 34°C.

offered distilled water or nothing at all. This phenomenon was more marked at lower (25°C.) than at higher (34°C.). Maximum longevity, however, was attained in flies fed on citrated blood, while those left without food showed the lowest longevity. There was a striking difference between the longevities of flies given 10% sugar syrup and those of flies given distilled water. At 25°C., the average longevity was nearly 6 and 4.1 times longer in the sugar-solution-fed flies as compared with nonfed ones and water-fed group respectively. Flies fed on citrated calf blood had maximum longevities of 504, 336 and 96 hours at 25, 30 and 34°C. respectively. The corresponding figures for sugar-fed flies were 373, 143 and 79 hours. The maximum length of life in the water-fed group and in the nonfed one were considerably shorter, being 43, 32 and 21 hours and 26, 24 and 22 hours at the same temperatures, respectively.

IX. MATING AND SEXUAL BEHAVIOUR

In *S. calcitrans* and *sitiens*, mating occurs in nature from March to June, when the atmospheric temperature ranges between 20 and 30°C. "Lasting" copulation (in which the male and the female remain in copula for a long time at rest), was never observed, but the male was noticed to fly occasionally near the female, darting suddenly above it and conjugation takes place in fraction of seconds while the couples are in the air. It appears that when the couples are in the air, the actual mating process takes place. This process may be compared with the "play flight copula" of WILHELMI (1917), in which the copulation of *calcitrans* takes place during a short interval after which the couples separate. WILHELMI (1917) is inclined to believe that this type of copulation leads to fertilization, he also added that the lasting copula was comparatively rare. MITZMAIN (1913), has never observed the mating of *S. calcitrans* under field conditions except in one case while the female was attempting to feed. BISHOPP (1939), however, stated that copulation takes place while the couples are not on the host. Under controlled conditions at about 30°C., males of the two species show a tendency for copulation nearly three days after emerging from the puparia. Among many numerous experiments carried out at this temperature, two *calcitrans* flies were noticed in "lasting copula", extending over fifteen minutes.

In the act of mating, the male hovers around the female and then approaches it suddenly adhering its genitalia violently into the female genital opening. It then rests on its back grasping the sides of the female with the fore and middle legs, while the hind pair of legs (tibiae and tarsi) supports the male firmly across the ventral surface of the abdomen. During the actual process of mating, the clasping organ of the male exerts a pressure forward and at the same time the female genitalia moves backward. At the end of coitus, the male withdraws its penis by a violent downward pull and releases its hind legs and flies away while the female remains for a time during which it protrudes its ovipositor in a telescopic action. It was observed experimentally that the same male may couple with more than one female, but it seems that the latter cannot be coupled more than once. The same phenomenon was noticed by SÉGUY (1935). From repeated observations, it was noticed that the males of *S. calcitrans* and *sitiens* are very ardent and copulatric, but the females are often disinclined and thwart the most determined male by simply keeping the abdomen close to the substratum and buzz him when he attempts to mount. It appears that this disinclination is due to the violence of the process of coitus. From this point *Stomoxys* resembles *Glossina.*

X. PRE-OVIPOSITION PERIOD

The duration of the pre-oviposition period of *S. calcitrans* was roughly determined by some of the previous workers, e.g. MITZMAIN (1913), who found in

March and April that the actual age of the fly at the time of egg-laying was 9 days. GLASER (1923) showed that the pre-oviposition period varied from 9-13 days with a mean of 10 days; YOKOO and HOTARI (1941) referred that it took about 20 days. However, LARSEN and THOMSEN (1940), could not determine the pre-oviposition period owing to the difficulty experienced in providing natural conditions to the adult flies.

The pre-oviposition period of *S. calcitrans* was studied at 25 and 30 °C. Newly emerged flies from pupae incubated at 30 °C. and 90% R.H. were placed in battery jars 10 × 15 × 20 cm., covered with muslin. The flies were fed daily on citrated calf blood. As a rule 10 young males and 10 young females were used in each experiment and in some cases two or three old males (marked with colours on wings) were added in order to stimulate mating. The time when conpulation commensed was observed. Shortly after copulation a Petri dish containing fresh horse dung with a high moisture content was placed in each jar and renewed daily. Observations were carried out hourly and when eggs were met for the first time in the manure, the time was recorded. The span of life elapsing from emergence to the first egg-laying was recorded as the pre-oviposition period. The results are shown in Table VII, from which it appears that at 30 °C. the pre-oviposition period ranges between 4.5 and 6 days with an average of 5.5 days. At lower temperature e.g. 25 °C., the period is somewhat prolonged varying between 6 and 8 days with an average of 7.9 days.

TABLE VII

The pre-oviposition period of S. calcitrans *under different temperatures* (25 and 30°C).

Temperature in °C.	Number of observations	Pre-oviposition period in days		
		Min.	*Max.*	*Average*
30	20	4.5	6	5.5
25	20	6	8	7.9

XI. OVIPOSITION AND FECUNDITY

A. Habits of the female during oviposition

Under controlled condition at 30 °C., the females of both species takes a full meal after copulation. It usually crawls into the loose substratum of the dung preferring those of higher moisture content, sometimes going to a depth of one inch. Before ovipositing, the fly usually partakes some of the dung juice, after which it greatly extends its ovipositor in a downward curved fashion and uses it as a tactile organ to select a suitable spot. The eggs are laid either in bunches or in single

ones. During the act of egg-laying, it is noticed that the female usually moves occasionally so as the egg masses are scatteringly deposited. It also prefers the dark situations for this process and the sudden exposure of the fly to light during oviposition is sufficient to prevent egg-laying. Immediately after oviposition the fly protrudes its proboscis and when blood is offered, it feeds voraciously till it becomes engorged. It was also noticed that the number of blood meals taken to induce oviposition varies with the different seasons, being more in cold months than in hot weather.

In the field it was noticed that the adults appear to have a strong sense of smell and are able to detect moist straw and suitable ovi-positing media very quickly. This was cleaily noticed when the upper dry crust of a horse bedding was opened so as to expose the moist decaying interior. Very soon after opening, the flies were attracted to the dark moist layers in numbers and started to oviposit. Usually they crawl into the loose straw, sometimes going to a depth of two inches.

B. Fecundity

The number of eggs laid by a single female, was determined under laboratory conditions. At first, gravid captive females of *S. calcitrans* and *sitiens* were used. Monthly fly catches were made and gravid females were transferred to the laboratory and provided with horse dung. After oviposition, the eggs were counted. From the results obtained, it seems that under conditions prevailing at Abu Rawash farm, the number of eggs deposited by a single female differed according to the seasons of the year. The rate of oviposition of *S. calcitrans* is markedly low in winter mainly in January (10 eggs in average), but rises gradually in the spring reaching its hight (86 eggs, average) in May after which a gradual fall takes place during late summer and autumn. In *S. sitiens*, the peak of egg-laying occurred a month later in June, when the deposited eggs were 92. Similar to *calcitrans*, the lowest number of eggs laid (12.8 in average) was recorded in December and January (14 eggs, average), but it should be pointed out that the number of eggs laid by *sitiens* during the different months were distinctly higher than those laid by *calcitrans*. Thus the average number of eggs laid by *S. sitiens* were 14, 34, 42, 51.2, 75, 92, 72, 40, 35, 32, 25 and 12.8 in January, February, March, April, May, June, July, August, September, October, November and December of the year 1955, respectively. The corresponding figures of *calcitrans* were 10, 30, 40, 49.8, 86, 72, 70, 30, 32, 30, 20 and 11.6.

Fecundity under controlled conditions

The possible effect of temperature on the number of eggs laid per female was tested in series of experiments. In each experiment one young female and 10 males were placed in a battery jar. The dung was removed daily and examined under binocular. When eggs were found, they were counted. Adults were taken from a stock of pupae incubated at 30°C. and 90% R.H. The experiments were carried out in dark

incubators. The temperatures used were 22, 25 and 30°C. The average number of eggs laid per female seems to be greatly affected by variation in temperature (Table VIII). At 22 °C. a reduction in the average number of eggs was noticed. While at

TABLE VIII

Showing the effect of temperature on fecundity.

Temperature in °C.	Number of experiments	Average total eggs per female			
		Number of depositions		Total number of eggs	
		calcitrans	*sitiens*	*calcitrans*	*sitiens*
22	10	3.0	4	95	100
25	10	4.0	5	120	150
30	10	4.5	6	200	250

30 °C., on the other hand, females yielded the greatest output of eggs. For instance, the number of eggs laid by *calcitrans* at 30 °C. was about 2 times its value at 22°C. and at 25 °C., it was nearly 1.3 times. In S. *sitiens*, the number of eggs laid was higher. Thus at 30, 25, and 22°C., the female laid 250, 150, 100 eggs, respectively, as compared to 200, 120 and 95 in *calcitrans*. The same phenomenon was observed on the total number of egg deposition. For instance, with the rise of temperature, there was an increase in the number of egg-layings. Thus at 22, 25 and 30°C., *S. calcitrans* made 3, 4 and 4.5 (average) depositions, respectively, while the corresponding figures of *S. sitiens* were 4, 5 and 6 depositions. The maximum number of eggs laid by a single female was 200, 250 eggs for *calcitrans* and *sitiens*, respectively, and this occurred at 30°C. In addition to the eggs laid, there was present after death a fairly large number of eggs in two females dissected. The contents of the egg chamber in the dissected ovarian tubes were counted. The chains of immature ova were not taken into consideration. In *calcitrans*, the contents of the ovaries of the fly which laid 200 eggs, consisted of 20 ripe and 30 partially developed ones, thus making a total of 250 eggs which might be considered the maximum number of eggs produced by a female *S. calcitrans* during its life. In *S. sitiens*, the corresponding figure was higher; the female which laid 250 eggs still retained 30 ripe and 60 partially developed eggs, making a total of 340. PORTSCHINSKY (1910), reported that the total number of eggs laid by a female *calcitrans* was 116. MITZMAIN (1913), however, showed that the maximum number of the total output of eggs was 632, but after dissection, this number reached 820. He also added that the total number of eggs laid by laboratory bred flies did not approach the maximum number deposited by the captive ones. He again stated that a fly which laid 106 eggs, showed on dissection 71 ripe, 112 half developed and 840 immature eggs; a total of 1123 eggs from one female *calcitrans*. In his opinion this number should

not be accepted as the possible maximum number of eggs that would be deposited, and he was more inclined to consider 820 as the more arithmatic number. WILHELMI (1917) showed that a female *calcitrans* made 9 ovipositions with a number of eggs ranging from 86 and 130. SÉGUY (1935), considered 250 eggs representing the total number of eggs given by one *S. calcitrans*. BISHOPP (1939), noticed that the greatest number of eggs laid during the life of *calcitrans* was 620.

XII. SEX RATIO

A. Seasonal variation in sex ratio at Abu Rawash farm

The procedure used to determine the proportion of sexes was mentioned in the methods and material (Chapter II). The results obtained show clearly that in *S. sitiens*, the percentage of females usually exceeds that of the males, but the difference between the percentage of sexes is more marked in January, February, March and November (cold months), when the percentage ratios of males to those of females are 32-68, 29-71, 31.5-68.5 and 32.5-67.5, respectively. On other months of the year, e.g. April, June, August, September, October and December, the male/female ratios are 41-59, 49.5-50.5, 45.3-54.7, 46.7-53.3 and 52-48%, respectively. These figures show that in the majority, the percentage of females slightly exceeds that of the males and the deviation from 1: 1 sex ratio seems to be rather slight. In May, however, the number of males slightly exceeds that of the females where the percentage is 53-47%.

In the case of *S. calcitrans*, the number of females, in most months exceeds that of the males. For instance, in January, March, July, August, October, November and December, the percentage of males to females is 24-76, 39.5-60.5, 36.7-63.3, 37.5-62.5, 26.7-73.3, 42.5-57.5 and 34-66, respectively. While in February, May, June and September, the corresponding figures of ratios of males to females are 51-49, 50.3-49.7, 58.5-41.5, 55-45 and 52-48%, respectively. From the foregoing data, it appears that in most months of the year, females of *S. calcitrans* prepondrate and manifest themselves, in almost all cases, in far greater number than the males. WILHELMI (1917), working in Germany, noticed that the percentage of the females apparently increases until November; from June to August more males were produced. However, he was more inclined to believe that males and females are produced in about equal numbers.

In the case of *S. sitiens*, the percentage of the females again exceeds that of the males, particularly, in the cold season of the year.

B. Diurnal changes in sex ratio of *Stomoxys* at Abu Rawash farm

The procedure used to determine the diurnal changes in sex ratio was mentioned in Chapter II. The observations were conducted throughout the year 1956. The results obtained show that:

In *winter* (e.g. December), the number of females of both species slightly exceeded that of the males, and the difference between the number of two sexes was higher in *S. sitiens* and reached its peak at 3 p.m.

In *spring* (e.g. March), the number of females also generally exceeds that of the males, but the difference between the number of sexes becomes more obvious, reaching its height at 4 p.m. in *S. sitiens* and at 10 a.m. in *S. calcitrans*.

In *summer* (e.g. July) the number of males *S. calcitrans*, with few exceptions exceeds that of the females. The difference between the two sexes is higher at 8 a.m. and 6 p.m. In *S. sitiens*, on the other hand, the number of females markedly exceeds that of the males. The difference in number between the two sexes reached its peak early in the morning (5 a.m.) and late in the afternoon (7 p.m.) when these peaks were 78 and 915 respectively.

In *autumn* (e.g. October), the number of females, markedly of *S. calcitrans*, slightly exceeds that of the males, but the difference is generally very small. In the case of *S. sitiens*, the number of females markedly exceeds that of the males, but this is more pronounced in the early morning and late afternoon, but in the latter case, however, the difference between the number of sexes is distinctly higher.

From the foregoing results it appears that the females generally prepondrate and that the diurnal change in sex ratio of *Stomoxys* follows a more or less regular pattern. Thus generally in cold months, the difference between the two sexes, increases slightly about midday, while in hot weather, it is high in the morning and late afternoon. It is clear, however, that these differences are markedly higher in *S. sitiens*; a phenomenon which indicates that in Abu Rawash farm, this species occurs in higher density than *calcitrans*.

C. Sex ratio under controlled conditions

The sex ratio of both species of *Stomoxys* was studied under controlled conditions in two series of experiments, each comprised three tests. In the first

TABLE IX

Sex ratio in S. calcitrans *and* sitiens, *emerging from a stock bred at two different temperatures* (20 and 30°C.)

Temperature in °C.	Number	*sitiens*				*calcitrans*			
		Male	Female	Male	Female	Male	Female	Male	Female
20	1	30.0%	70.0%			50.0%	50.0%		
	2	32.6%	67.4%	28.9	71.1	49.0%	51.0%	47.2	52.8
	3	24.2%	75.8%			42.6%	47.4%		
30	1	45.0%	55.0%			60.0%	40.0%		
	2	40.0%	60.0%	42.6	57.4	45.5%	54.4%	52.3	47.7
	3	43.0%	57.0%			51.4%	48.6%		

series, the adults were taken from a stock kept at 30 °C., and were allowed to oviposit, and the eggs were left to complete the life-cycle at the same temperature. In the second series, the adults were taken from a culture kept at 20°C., and the early stages of which were bred under the same temperature. On emergence, the adults bred under each temperature were collected and the sexes were separated and the average percentage of each sex was estimated. The results are shown in Table IX. From this Table, it appears that the average percent of females *S. sitiens*, emerged at lower temperature is markedly higher than that of the males, being 71. At higher temperature 30°C. the percentage of females slightly exceeds that of the other sex, being 57.4. In the case of *S. calcitrans*, at 20°C., the average percentage of females to males was 52.8 to 47.2, while at 30°C., it was 52.3 to 47.7.

From the foregoing results, it seems that *S. sitiens* yields females in greater numbers than males, particularly at lower temperature. In *S. calcitrans*, on the other hand, the deviation from 1:1 sex ratio (at both temperatures), seems rather small and not well marked.

XIII. SUGGESTIONS ON CONTROL MEASURES AGAINST *STOMOXYS*

The fact that *Stomoxys* is a great nuisance to domestic animals inflicting upon them painful bites and possibly transmitting to them a number of virulent diseases, necessitates effective control measures against it.

The foregoing ecological studies may provide a sound basis for control, and point out with sufficient clarity, as to when and where successful campaigns for the abatement of *Stomoxys* may be launched.

A. Measures against the breeding grounds of *Stomoxys*

It was found that under conditions prevailing in this country, both species of *Stomoxys*, breed chiefly in (1) horse, donkey and cattle beddings, especially when mixed with urine, (2) decaying vegetable matter, especially the leaves which fall on soggy soil, and (3) fermenting plants and straw piled along canal banks.

In the light of these findings, the following may be advocated in order to reduce *Stomoxys* breeding: (1) First, it is important to note that, the pregnancy among *Stomoxys* flies reaches its peak in May and June. Therefore effective control measures against this fly with the complete destruction of the ovipositing media, must be increased during these months. Meanwhile, it should be always borne in mind, during this period and throughout the year, that the chief breeding media must be sought for in sunny areas in winter and shaded ones in hot season. (2) Animal beddings may be renewed twice weekly; the old bedding should be spread into thin layers and exposed to the strong heat of the sun. Since the larvae of *Stomoxys* require excessive moisture and moderate temperature, they would die immediately. After about 3 days of exposure, the straw could be utilised again instead of

the previously used bedding. In stables and byres, where larvae of *Stomoxys calcitrans* occur in smaller numbers, in addition to the regular renewing of the beddings and their exposure to the sun, also larvicides such as phenol or borax may be sprayed over the beddings. (3) At Abu Rawash farm and in similar farms, the falling leaves in the artificial forest, when come in contact with the soggy soil underneath, form a fermenting layer which contains numerous larvae and pupae. Therefore, and in the breeding season (May and June), it is advocated to prevent water from reaching the soil of the forest, and at the same time, the falling leaves could be collected by the farm labourers and burnt. This measure is of the utmost practical importance, as there is every likelihood that this artificial forest does not only serve as a breeding focus for *Stomoxys*, but for other flies and mosquitoes invading the region of Cairo. (4) Fermenting plants, especially those lying on the canal banks should be collected and burnt.

B. Measures against the adult flies

1. In the open

When an insecticide is desired to be used against the flies in the open, the best time of the year recommended for application is the spring (May and June), when the fly abundance reaches its peak (Fig. 11). In these months, it is better to apply the insecticide both inside the forest among the trees and bushes, and outside it in the open. The former may be used at mid-day when the outside temperature exceeds 30°C., and the flies seek cooler and shaded places. The latter may be used in the early morning (from 8-11 a.m.) and late after-noon (from 6-7 p.m.) when the flies are very abundant in the open (See Figs. 7-10).

2. On the body of their hosts

VANDERPLANK (1947 c) in Shinyanga and Tanganyika, investigated that, if one could treat cattle with DDT emulsion and graze a sufficient number in fly belt, one might hope to exterminate the tsetse fly in a limited period. He also showed if the dose is high, an exposure of few seconds may indeed be sufficient to kill the fly. BUXTON (1955) reported that on evaporation, the DDT could be observed as crystals. After the tsetse fly had alighted on these crystals, the latter could be observed among the hairs of the pulvilli of the insect's tarsus. There is some evidence that, it is the small crystals of DDT caught up among these hairs that are responsible for the toxic effect. In the light of these facts, and the results obtained on the biting cycle of *S. calcitrans* and *sitiens* flies by the present authors (HAFEZ and GAMAL-EDDIN, 1958 b), it may be recommended to treat the cattle (especially the legs; the preferred parts for biting) in a heavily infested area, with DDT emulsion. This method must be applied in late spring mainly May and June, when both species of *Stomoxys* manifest themselves in extreme abundance. The spray-painted animals are left to graze in the open in the early morning (8-11 a.m.) and late after-noon (6-7 p.m.), when the biting activities of both species reach their maxima

(HAFEZ and GAMAL-EDDIN, 1958 b). At noon, these painted animals may be directed towards the artificial forest when congregations of *Stomoxys* flies seek shelter from the mid-day heat in the open.

XIV. SUMMARY

Ecological and biological studies have been conducted on *Stomoxys sitiens* and *calcitrans* in Egypt. The results obtained are summarised as follows:

1. The normal environment and the climatic conditions

Stomoxys flies live in different localities in this country, but one of these localities where the flies manifest themselves in extreme abundance, is a sewage farm (Abu Rawash farm), west of Cairo and about 20 kilometres north west of the great pyramid of Giza. The flies live mainly in an artificial forest, which forms a typical resting, feeding and breeding ground for both species of *Stomoxys*.

The climatic conditions prevailing in this farm are as follows:

(a) The seasonal variation in air temperature has a wide range; thus the lowest temperature (1.2°C.) was recorded in January 1955 and the highest was 41.6°C. in July of the same year.

(b) Relative humidity reached its maximum (96% R.H.) in January 1956, and its minimum (2%) in April of the same year.

(c) The maximum amount of evaporation (20.2 cc./day) was recorded in June 1956 and the minimum (1.4 cc./day) in January.

(d) The locality was subjected to long period of complete drought, thus in 1955 rain fell on 11 days and the total amount of rainfall was 16.6 mm.

2. Habits of the adult

Both species are typically outdoor insects, *S. sitiens* however, prefers the cultivated semi-arid localities, especially those lying on the desert edge. The fly activity in the sun is a thermotropic response than a phototropic one. Also both species are negatively heliotropic in hot months and positively so in cold seasons.

3. Breeding season in nature

The peak of breeding of *calcitrans* was reached in May, while in *sitiens* it occurred a month later, in June.

4. Breeding media

Cattle, horse, donkey dung when mixed with straw and wetted with urine, and decaying plant leaves form an attractive ovipositional and breeding media for both species of *Stomoxys*.

5. Diurnal rhythm and seasonal variation of the adults

Both *S. calcitrans* and *sitiens* have each one annual peak of seasonal abundance, being May and June, respectively. the number of both species reaches its minimum in January. Also it was found that, in hot months, the flies, particularly *sitiens*, increase in number early in the morning and late in the afternoon, but in the latter case, in almost all cases, the peak is distinctly higher. In winter, the peak of both species occurs only once during the day at about 2-3 p.m.

6. Longevity

Under room conditions (17-19°C.), the female fly of *calcitrans* lived about 412.7 hours and the male 621.2 hours.

7. Pre-oviposition period

At high temperature 30°C., it averaged 5.5 days, while at 25°C., the period averaged 7.9 days.

8. Oviposition and fecundity

At 30°C., the number of eggs laid by *calcitrans* was 200 and at 25°C., was 120 eggs. In the case of *sitiens*, it laid higher number (250 and 150 eggs at 30 and 25°C., respectively).

9. Sex ratios

Under controlled temperature, *sitiens* flies yield females in greater number, particularly, at lower temperature. In *calcitrans* the deviation from 1: 1 sex ratio seems rather small and not marked.

10. Suggestions on control measures against *Stomoxys*

Control measures by destroying the ovipositing media or by insecticidal spraying must be intensified in May and June when the breeding season reaches its peak. Meanwhile, the media favoured by the fly for breeding must be sought for in sunny areas in winter and in shaded ones in the hot season. DDT painted animals used as poison bait for the flies may be left to graze during the breeding season early in the morning and late afternoon when the biting activities are highest.

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SUR LA PRÉSENCE DES "DEMI-REINES" CHEZ L'ABEILLE ÉGYPTIENNE: *APIS MELLIFICA FASCIATA* LATR.

(avec 1 Figure)

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INTRODUCTION

VOGEL (1865) et plus tard ROTTER (1921) ont noté qu'il existe chez l'*Apis mellifica fasciata* Latr. des demi-reines (Halbköniginnen) à côté de la reine mère dans la ruche. La demi-reine est un peu plus petite de taille que la reine propre. Les deux ont la même forme, mais le scutellum de la demi-reine est rouge-brunâtre comme chez les ouvrières. Les demi-reines émergent des cellules des ouvrières, vivent pacifiquement à côté de la reine normale et participent avec elle dans la déposition des oeufs. Les œufs de ces demi-reines donnent des mâles seulement.

GOUGH (1916) a travaillé pendant plusieurs années en Egypte avec l'*Apis mellifica fasciata* Latr. et il n'a pas mentionné l'existence de ces êtres mystérieux à côté de la reine mère dans la ruche.

V. BUTTEL-REEPEN (1921) a pu obtenir deux ruches d'abeilles égyptiennes. Elles ont vécu en Allemagne plus d'une année dans leurs conditions naturelles. Toutefois, il n'a pas observé les demi-reines décrites par VOGEL et par ROTTER, mais il a pourtant dit (p. 50): "Hiermit ist die Frage naturlich nicht geringsten geklärt, dazu bedürfte es viel eingenhenderer Versuche. Vor allem müsste in Ägypten dernach geforscht werden".

HASSANIEN et EL-BANBY (1956) ont étudié la Morphologie et la Biologie de l'abeille égyptienne élevée dans des ruches en boue et dans des ruches à rayons mobiles. Ils n'ont pas signalé l'existence des demi-reines chez l'*Apis fasciata*.

Une étude détaillée de ce problème du point de vue biologique en Egypte était donc nécessaire.

Matériel et méthode

Dans ce but dix colonies d'*Apis mellifica fasciata* Latr. ont été obtenues de la Basse et de la Haute-Egypte: Mansourah, Chebin-El-Kom, Kalioub, Beni-Suef, Menia, Souhag et Luxor. Elles sont élevées dans des ruches de Langstroth aussi bien que dans des petites ruches d'observation (type modifié de v. FRISCH, 1923) (Fig. 1). Il fallait, d'une part, laisser les abeilles travailler dans les conditions les plus naturelles et, d'autre part, examiner les ruches régulièrement.

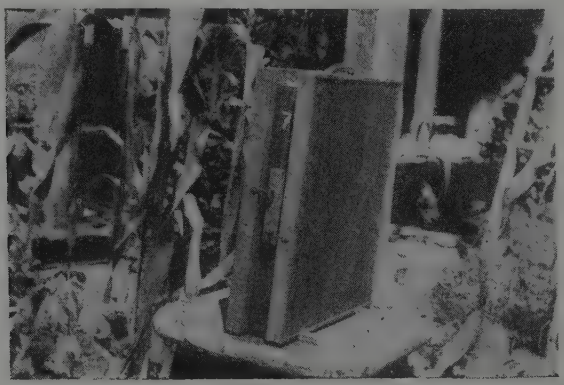

FIG. 1: Petite ruche d'observation.

Résultats

L'observation des phénomènes naturels à l'intérieur des ruches va nous donner la possibilité de faire quelques constations très intéressantes:

(1) Il est rare que la colonie d'abeilles européennes donne plus de six à douze reines en même temps, tandis qu'une colonie d'abeilles égyptiennes donne normalement de cent à deux cents reines. Nous avons même pu compter une fois plus de trois cents reines dans la même ruche.

En examinant une ruche qui est en train d'essaimer, on trouve toujours de nombreuses reines courant parfois en centaines ; ce sont des reines vierges et non des demi-reines.

(2) Une fois fécondée, la reine d'une colonie d'abeilles égyptiennes devient plus intolérante pour les reines vierges que la reine d'une colonie d'abeilles européennes. Parfois même, nous avons pu observer des ouvrières aidant la reine mère à chasser les reines vierges de la ruche.

(3) En cas de mort de la reine mère, les ouvrières commencent immédiatement l'élevage de nouvelles reines, en se servant des oeufs ou de jeunes larves âgées de moins de trois jours. S'il n'y en a pas dans la ruche, c'est une ouvrière (parfois

plus) qui sera traitée comme une reine. Ceci semble arriver plus librement chez l'abeille égyptienne que chez l'abeille européenne. L'ouvrière pondeuse dépose plusieurs oeufs (parfois plus de huit) dans chaque cellule. Les larves qui se développent de ces oeufs donnent uniquement des mâles.

(4) Dans dix colonies de l'*Apis fasciata* et durant deux ans nous n'avons pas trouvé une seule demi-reine semblable à celle décrite par VOGEL et par ROTTER.

(5) Il est impossible que dans les cellules des ouvrières de l'abeille européenne qui sont plus grandes que celles de l'abeille égyptienne, se développent des demi-reines ou des individus en forme de reines. A cet effet, nous avons remplacé plusieurs fois, dans deux ruches à rayons mobiles, à partir de fin Février jusqu'au début Novembre, les deux cadres du milieu par deux autres cadres construits d'*Apis mellifica ligustica* Spin. Il s'en est suivi les faits suivants: (a) le nombre des mâles qui émergent des cellules des cadres d'abeilles européennes est assez grand; (b) aucune demi-reine ne s'est développée dans ces deux ruches.

Discussion

Ces faits contredisent donc les affirmations de VOGEL et de ROTTER "...Dass in *fasciata*-Völkern neben der eigentlichen Mutter noch Halbköniginnen existieren, die etwas kleiner als die normale Mutter sind, ihr jedoch sonst an Gestalt vollkommen gleichen, aber in Gegensatz zu der eigentlichen Königin anstatt einem dunkel gefärbten Scutellum ein rotgelbe gefärbtes besitzen. Diese mysteriosen Wesen, die aus Arbeiterinnenzellen schlüpfen, leben in einigen Exemplaren neben der regulären Mutter friedlich im Stock und beteiligen sich mit an der Eierlage. Aus den Eieren derselben gehen jedoch nur drohnen hervor, ..." (ROTTER 1921, p. 6).

Mais comment expliquer alors les observations de ces deux auteurs ?

Dans les ruches sans reine, nous voyons souvent à côté des cellules royales une activité particulière sur les cellules des ouvrières qui agrandit leurs opercules. Toutefois, dans ces cellules agrandies, comme dans les ruches avec cadres d'abeilles européennes dont les cellules des ouvrières d'*Apis ligustica* sont plus grandes que les cellules des ouvrières d'*Apis fasciata*, ne se développent que des ouvrières normales.

VOGEL insiste sur le fait que les demi-reines émergent des cellules des ouvrières. Or, les observations décrites ci-dessus nous permettent de formuler les deux hypothèses suivantes : (A) ou les demi-reines sont des ouvrières pondeuses qui se développent dans la ruche à la suite de l'absence de la reine mère; (B) ou les demi-reines sont des reines vierges qui, chez l'*Apis fasciata*, existent en grand nombre (quelquefois en centaines) à côté de la reine mère dans la ruche. La première hypothèse est appuyée par ces faits tirés de la description donnée par VOGEL et par ROTTER: (a) les demi-reines émergent des cellules des ouvrières; (b) elles ne s'accouplent jamais; (c) et, leurs oeufs donnent des mâles seulement. La deuxième hypothèse est appuyée, par ailleurs, par le fait que les demi-reines sont semblables en forme à la reine propre de la ruche, et sont plus grandes en taille que les ouvrières. Or, comme il

est évident que les reines vierges ne pondent pas, il semble clair que ces demi-reines sont tout simplement des ouvrières pondeuses.

ROTTER s'appuie principalement sur la couleur la plus pâle du scutellum et sur la taille plus petite que celle des reines normales. Mais cela n'est pas une preuve décisive car (a) il y a des reines mères d'*Apis fasciata* qui sont un peu pâles (voir v. BUTTEL-REEPEN, 1906, p. 20); (b) et, chez les ouvrières d'*Apis fasciata*, le scutellum va du jaune au jaune-rougeâtre. Donc, il ne suffit pas de s'arrêter à la couleur et à la taille des reines mères qui varient fortement.

Il est regrettable que ROTTER n'a pas poussé plus loin ses recherches sur les demi-reines. Une étude plus détaillée et plus précise fondée sur le nombre exact, les dimensions, la durée, etc., l'aurait certainement amené à d'autres résultats plus convaincants.

Résumé

Le présent travail nous permet de constater que:

(1) Les demi-reines décrites par VOGEL (1865) et par ROTTER (1921) n'existent pas chez l'*Apis mellifica fasciata* Latr. obtenue de la Basse et de la Haute-Egypte.

(2) L'ouvrière pondeuse de l'*Apis mellifica fasciata* Latr. ne diffère pas tellement des ouvrières normales de la colonie du point de vue morphologique. Leur existence dans la ruche est signalée par la présence de plus d'un oeuf dans chaque cellule. Les larves qui se développent de ces oeufs ne donnent que des mâles.

(3) L'abeille égyptienne donne un grand nombre de reines vierges à côté de la reine mère avant l'essaimage.

(4) Ces résultats permettent de confirmer que les demi-reines vues par VOGEL et par ROTTER chez l'*Apis mellifica fasciata* Latr. sont tout simplement des ouvrières pondeuses.

Summary

The biological observations which were conducted in Egypt for two successive years on the Egyptian honey-bee, *Apis mellifica fasciata* Latr., showed that:

(1) The half-queens refered to by VOGEL (1865) and by ROTTER (1921) do not exist in the colonies of *Apis mellifica fasciata* Latr. in both Lower and Upper-Egypt.

(2) The laying worker of *Apis mellifica fasciata* Latr. does not differ morphologically from normal workers. Its existence in the colony is only recognised by the presence of more than one egg in each cell. The larvae which emerge from such eggs develop to give drones.

(3) The Egyptian honey-bee usually raises huge numbers of queens. Before swarming they are seen running in the hive even in hundreds.

(4) The author is of the opinion that the halfqueens seen by VOGEL and by ROTTER in populations of *Apis fasciata* are laying workers.

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ON THE FEEDING HABITS OF *STOMOXYS CALCITRANS* L. AND *SITIENS* ROND., WITH SPECIAL REFERENCE TO THEIR BITING CYCLE IN NATURE

[*Diptera* : *Muscidae*]

(with 4 Text-Figures and 2 Tables)

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I. Introductory and historical. — II. Material and methods. — III. Sources of food. — IV. Mechanism of feeding. — V. The feeding period. — VI. The period of digestion. — VII. The biting cycle in nature. — VIII. Summary. — IX. Bibliography.

I. INTRODUCTORY AND HISTORICAL

In a previous paper on the ecology of *Stomoxys calcitrans* and *sitiens* (see this Bulletin, pages 245-254), the present authors have strongly emphasized the veterinary importance of both species as serious pests of our cattle and other domestic animals. They bite them severely and feed voraciously on their blood, leading sometimes to grave consequences culminating, besides disease transmission, in loss of flesh and milk production and in many cases interfering greatly with the usual daily work of the livestock on the farm. Therefore, it was found expedient to study more closely the feeding habits of these flies specially their biting activities during the day in the different seasons of the year. The results of our field observations and experiments are given and discussed in the present paper.

The literature contains valuable information about the feeding mechanism and habits of *S. calcitrans* notably in the works of STEPHENS and NEWSTEAD (1907), MITZMAIN (1913), HEWITT (1914) and SEN (1935). Short notes on the same subject were given by WILHELMI (1917), KRIJGSMAN (1930) and BISHOPP (1939).

As to *S. sitiens*, it seems that no studies on its feeding habits were given by previous authors. A preliminary study, however, describing the species as a new record to Egypt with a short note on its bionomics has been given by the present authors (HAFEZ and GAMAL-EDDIN, 1957).

II. MATERIAL AND METHODS

The method employed for keeping and feeding both species of *Stomoxys* in captivity in the laboratory was previously described by the present authors (see this Bulletin, pages 248-250).

To distinguish the normal preferred or dependable host from the casual one, sweepings were made on the legs of the animals for ten minutes catch at the time of increased biting activity of flies. The arithmatic mean of four different catches on four different days was considered as the fly index per animal.

In order to determine the relative intensity of the fly biting activities during the day, one donkey was used as a bait and sweepings for fifteen minutes hourly were made on the lower parts of the legs (the meta-carpal regions), beginning from early morning to sun-set. The hourly arithmatic mean of two catches on two successive days was considered as the fly index per hour. Most of the field studies were carried out in Abu Rawash farm south west of the great pyramid of Giza.

III. SOURCES OF FOOD

The results obtained are represented in Figure 1, from which it seems that *S. sitiens* depends on and highly prefers the donkey to any other animal for feeding and is usually infested by a large number of flies imbibing its blood. The least favoured animal was the goat; sheep with fleece intact was not as attractive to flies as the newly shorn sheep, the latter being always favoured for biting. The camel was second to the donkey in the order of preference, then followed the horse, buffalo, cow, sheep and goat. To *S. calcitrans*, donkey was still the preferred animal, followed by horse, buffalo, cow camel, sheep and goat. This means that some species of domestic animals are much freer from attack than others. This comparative freedom may be due largely to protection afforded by the hair (BISHOPP, 1939). KRIJGSMAN (1930), working on the tropisms of *S. calcitrans*, indicated that the odour of the host skin is the chief stimulus that induces feeding and also enables the flies to differentiate between one species of mammal and the other. Also it is

clear that the relative abundance of *S. sitiens* is far greater than that of *S. calcitrans*; thus the average number of individuals of the former species caught on donkey was about five times that of the latter species.

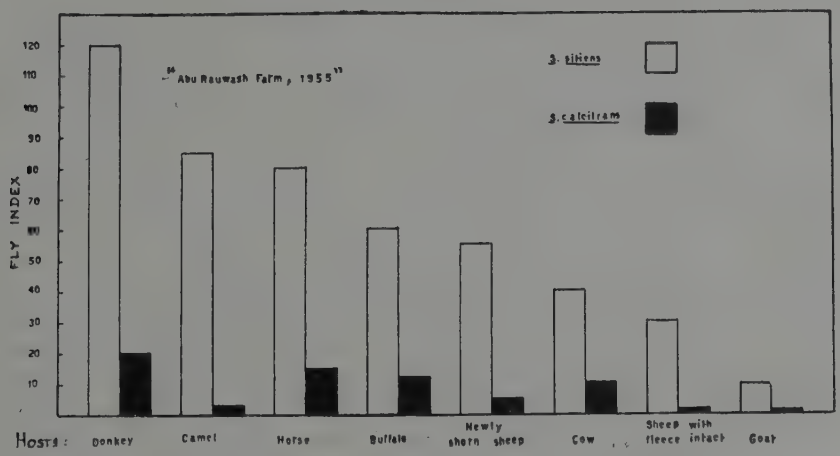

FIG. 1: Average numbers of *Stomoxys sitiens* and *calcitrans* (in a ten minutes catch) caught from animals.

The legs of animals especially the meta-carpal regions seem to be the highly preferred parts of the animal for feeding. The flies always aggregated on these parts in prodigious numbers. In the hot season, however, the flies shifted their feeding to the lower part of the abdomen, where they possibly seek shaded spots. The bites of the flies were seemingly severe, causing annoyance to animals; in many instances, these latter were seen running and kicking or standing in water, possibly to avoid the bites of the flies. BISHOPP (1939) has recorded the same phenomenon in America and reported that the joints of both cattle and horses became so swollen and stiff from standing in water to avoid the bites of the flies.

In the laboratory, the flies of both species fed on the blood of different species of vertebrates including mammals, birds and even reptiles. From these animals, they fed on man, guinea pig, cat, dog, rabbit, rat, bat, chicken, lizzards and *Chameleon vulgaris*.

The identity of the host on whose blood *Stomoxys* fed, was also established by examining blood films taken from the alimentary canal of the fly. By this method it was possible to identify the host, including those wild non-domesticated animals on which the fly might feed. These examinations of blood films revealed that in nature, both *S. calcitrans* and *sitiens* fed on man's blood and that of donkey, horse, sheep, goat, camel and dog. Blood taken from the crop of *S. calcitrans* col-

lected from the zoological gardens of Giza indicated that the fly fed on deer, monkey and fox.

IV. MECHANISM OF FEEDING

As the fly feeds, it throws its head well up and spreads its middle and hind legs to brace itself firmly, probably by gripping the rough surface of the skin with its claws. It then lowers the haustellum in a vertical position and is driven slowly into the skin. During the act of driving, it is rapidly moved up and down in the superficial layers of the skin and at the same time partially rotated from side to side in a straight manner. According to STEPHENS and NEWSTEAD (1907), these movements might be compared to those of a carpenter's auger with cutting flanges on either side, the only difference being that the movement in *Stomoxys* is not continuously rotating, but from side to side. During the latter process, the labella extend wide apart, thus exposing the rasps and prestomal teeth. Immediately afterwards, these organs are suddenly pressed downwards and tear the skin, driving the haustellum into the underlying tissues. It was noticed that the fly never fed after the first piercing, but partly withdrew the haustellum and thrusted it down into a fresh spot of the skin. In many cases, the insect was noticed to withdraw it, walk a short distance, feeling the skin with the labella and again pierced the skin. These ineffective acts of piercing may be repeated and last a minute or longer without imbibing blood.

It was noticed that the depth to which the haustellum is inserted varies and depends on the thickness of the epidermis. In the skin of guinea pig, the fly inserted the proboscis to the bulbous base, while in man's arm, only one third was driven. This difference in depth may be due to the location of the blood supply (HEWITT, 1914). It has generally been supposed that the haustellum passed through the tissues of the host till it chanced to enter a blood vessel from which the fly would suck the blood (Wilhelmi, 1917). The recent work of GORDON and CREWE (1948, a and b) on *Glossina palpalis* shows clearly that the fly does not take blood from a capillary, but causes a small haemorrhage which lies in horizontal planes beneath the dermis. They also added that the severe pain caused after the penetration of the haustellum inside the tissues may be due to the tearing activities of the labella inside the tissues of the dermis. The pain caused by *Stomoxys* on biting, may be explained along the same lines.

In some cases, especially in the young flies and weak individuals, the proboscis may be pierced in a deflected position during the whole meal. The same phenomenon was reported by HEWITT (1914).

When the act of sucking was completed, the insect quickly pulled the labium to its middle and then the rest was slowly withdrawn. MITZMAIN (1913) noticed the same behaviour, and HEWITT (1914) explained this phenomenon by su p-

posing that this slow movement might assist the insect to take up as much as possible of the extravasated blood rising up the puncture.

After feeding was completed, the proboscis was immediately dissected, and it was surprising to find that almost all the trophi and food canals were almost clean of blood. The same phenomenon was reported by BUXTON (1955) in *Glossina morsitans*; he explained it by stating "perhaps after the labella have been removed from the pool of blood, but probably while the haustellum is still in tissues, the fly discharges saliva and sucks it through the food canal which is cleansed in this way".

V. THE FEEDING PERIOD

The time elapsing from actual piercing till the withdrawal of the proboscis was found to vary considerably under different temperature conditions as shown in Table I. The feeding period of *S. calcitrans* decreased with the increase of temperature; thus at 30 °C., the period ranged from 3.5 to 12 minutes with an average of 7 minutes, while at 21°C., it ranged from 10 to 20 minutes with an average of 15 minutes. It was also obvious that the average feeding period in females was slightly longer than in males. WILHEMI (1917) reported that the female *S. calcitrans* sucks more blood than the male; also he added that the fly requires from 5 to 10 minutes to aspirate the blood. MITZMAIN, (1913) found that the feeding process lasts 1 to 3 minutes. HEWITT, (1914), without referring to the conditions of his work, found that the insect takes 8 to 9 minutes to complete feeding. SÉGUY (1935) found that the duration was 1 to 3 minutes.

TABLE I

Effect of temperature on the duration of feeding in Stomoxys calcitrans.

Temperature in °C.	Feeding period in minutes				
	Minimum	Maximum	Average	Mean	
				Male	Female
30	3.5	12	7	5.5	8.5
21	10	20	15	14	16

Comparing the feeding period of *S. calcitrans* with that of *Glossina morsitans*, it is noticed that the latter's is surprisingly short (25-100 second at 24-25 °C.), particularly when it is borne in mind that *Glossina* may imbibe blood more than its own weight (BUXTON, 1955).

VI. THE PERIOD OF DIGESTION

As the fly becomes gorged (within about 3 minutes of the commencement of feeding at about 30°C.), hyaline droplets of fluid were forcibly ejected from the anus and continued even after the fly has ceased feeding. BUXTON (1955), noticed the same droplets in *Glossina* and reported that this material excreted early was probably pure "urine" from the Malpighian tubules and not the actual digested blood. About 2.5 hours (at 30°C.), after the completion of feeding, these hyaline droplets were no longer clear, but changed to reddish brown; after some time these brown droplets ceased appearing and the clear hyaline droplets were voided again. HEWITT (1914) stated that the first appearance of digested food in *S. calcitrans* occurs in the form of brown faecal spots, and the completion of digestion is indicated by the cessation of the brown faecal deposits and the expulsion of the clear faecal spots again. From this, we can estimate the period of digestion of one meal, by recording the time elapsed between the commencement and the cessation of the brown droplets. Table II shows the period of digestion of one meal under two different temperatures (30 and 25°C.).

TABLE II

The effect of temperature on the digestion period of S. calcitrans

Temperature in °C.	Average period of digestion of one meal							
	Female				Male			
	Man blood		Calf blood*		Man blood		Calf blood*	
	Hours	*Minutes*	*Hours*	*Minutes*	*Hours*	*Minutes*	*Hours*	*Minutes*
30	14	36	7	32	14	24	8	40
25	21	11	10	10	24	32	14	19

*Each 1000 cc. of blood contained 100 cc. of 3% sodium citrate

At 30°C., when the adult was fed on man blood, a female digested the whole meal in about 14 hours and 36 minutes. When the temperature was lowered to 25°C., the mean digestion period was about 21 hours and 11 minutes. In the case of males, the mean time required for the digestion of one meal was about 14 hours and 24 minutes and 24 hours and 32 minutes at 30 and 25°C., respectively. When the adult was fed on citrated calf blood (each 1000 cc. of the blood contained 100 cc. of 3% sodium citrate) it was found that the period of digestion required for one meal was remarkably shortened nearly to about the half, as shown in Table II.

Judging by the results obtained from these laboratory experiments, the period of digestion, was nearly the same in both sexes especially at 30°C., HEWITT

(1914) working with *S. calcitrans* and without referring to the conditions of his work reported that the time required for the digestion of a full meal varied from 49 hours 45 minutes to 95 hours, with an average of 75.5 hours; a period which is much longer as compared to that obtained in the present work. Therefore, it seems that the period of digestion varies according to temperature and the kind of blood offered.

After feeding, the flies of both species settle down, with their body vertical and head upward, seemingly owing to the heavy load of the blood in the abdomen.

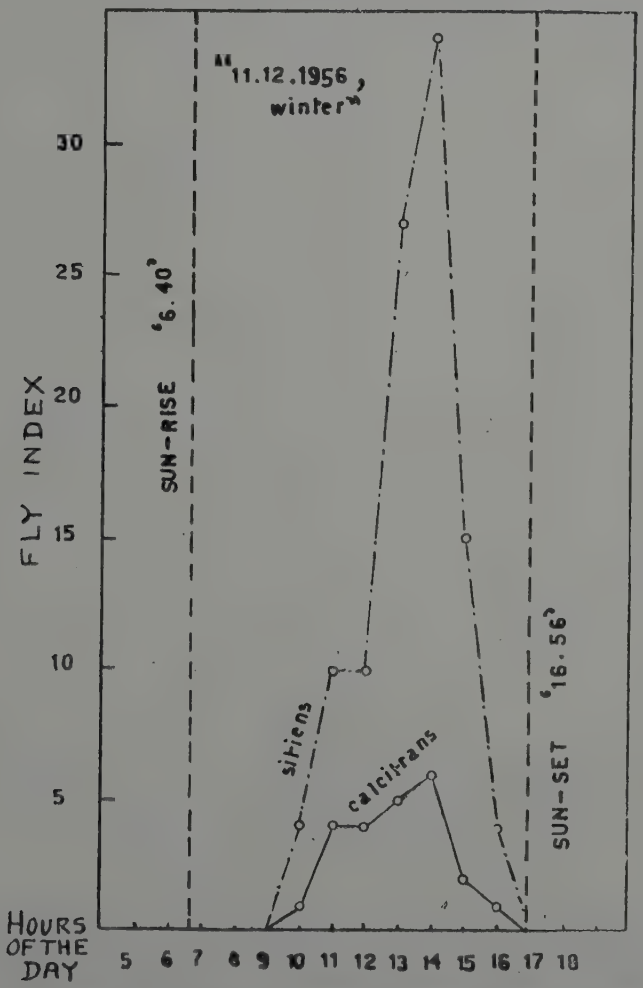

FIG. 2: Biting cycle of *Stomoxys sitiens* and *calcitrans* in nature, in winter.

It was also observed that such fully gorged individuals could only fly slowly and thus more subject to predatory insects and birds in nature.

VII. THE BITING CYCLE IN NATURE

The results obtained are represented in Figures 2-4. From these figures it appears that in the colder season of the year (winter months), there was a single peak, nearly in the early afternoon, as shown in Figure 2. About three hours after sunrise the flies of both species were entirely absent, after which the number of

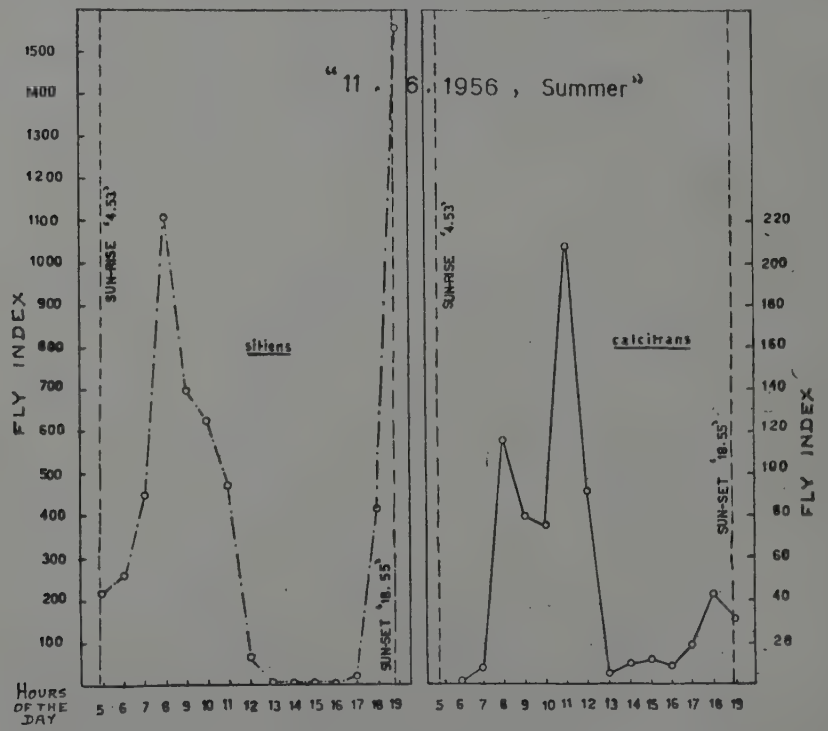

FIG. 3: Biting cycle of *Stomoxys sitiens* and *calcitrans* in nature, in summer.

feeding insects increased gradually reaching its height about 2 p.m. Immediately afterwards, an obvious fall took place reaching its minimum at 4 p.m.; at 5 p.m., the fly biting activity was stopped completely. It may be pointed out that the *sitiens* peak was about 5 times greater than that of *calcitrans*. In hot seasons (summer

and early autumn), on the other hand there were two peaks, one in the early morning and one in late afternoon, with a marked drop about noon. For example, on 11.6.56, *S. sitiens* flies appeared on the donkey about 4.5 a.m., increased gradually reaching their maximum at about 8 a.m., being six hours earlier than in cold days.

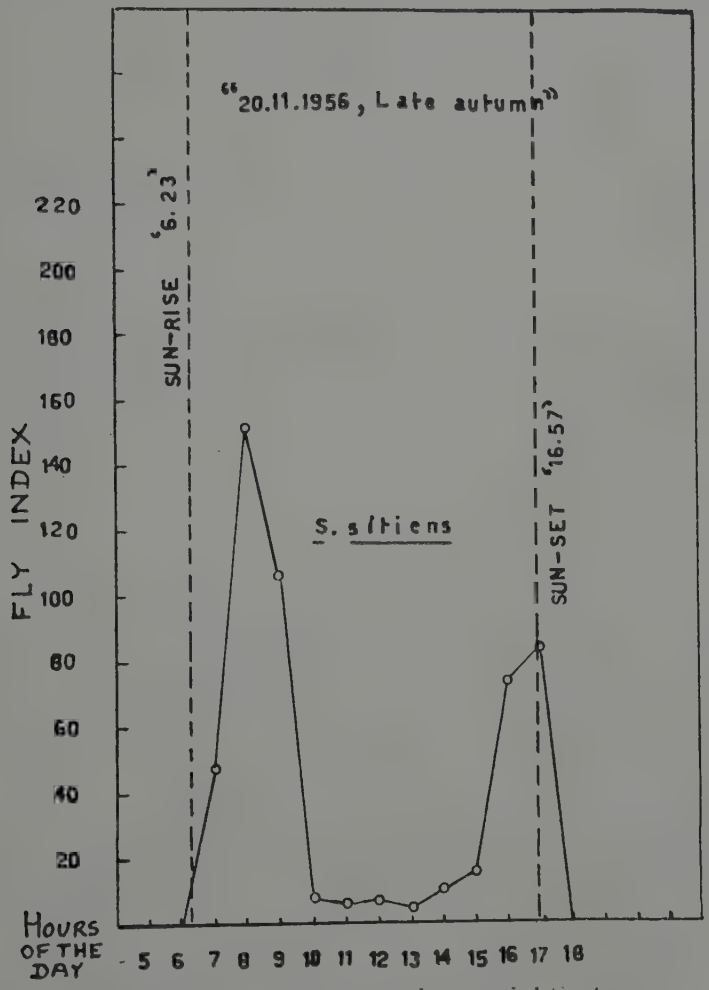

FIG. 4: Biting cycle of *Stomoxys sitiens* in nature, in late autumn.

After this morning peak, the numbers attracted to the donkey decreased gradually to practically nil until 5 p.m., where there was again a rapid increase, reaching its second peak at 7 p.m., after which an obvious sudden fall took place. Most

remarkable was the fact that in these hot months, it was noticed that the biting activity of *S. sitiens* usually reached its maximum at the time of sun-rise and sun-down, but in the latter period, however, the peak was distinctly higher (Fig. 3). On the advent of the cold season the peak was distinctly higher at sun-rise (Fig. 4). It appears that this reversal of peaks of the biting activities with the approach of cold months, was greatly correlated with temperature, being more suitably warmer at sun-rise than at sun-down. It was noticed that the highest biting activities of *S. sitiens* occurred mostly at about 27°C.

Comparing the biting cycle of *calcitrans* with that of *sitiens*, it was noticed that in hot days e.g. 11.6.56, *calcitrans* flies appeared feeding on the blood of the bait (donkey) at 6 a.m, (about 2 hours later than *sitiens*), reaching their maximum at about 11 a.m. After this morning peak the number fell, rising again gradually, and reaching a second, though distinctly lower peak at 6 p.m. (one hour earlier than *sitiens*). It was also obvious that the temperature at which the highest biting activities of *calcitrans* occurred was about 30°C., which was somewhat higher than that of *sitiens* (27°C.). When the temperature at the time of collecting was below 14°C., the flies were not attracted to the bait for feeding. WILHELMI (1917), reported that blood sucking by *S. calcitrans* started at temperatures above 15°C. When the temperature exceeded 34°C., the biting activities of the two species were clearly diminished.

VIII. SUMMARY

S. sitiens depends on and highly prefers the donkey blood to any other animal. The camel was the second to the donkey in the order of preference, then the horse, buffalo, cow, sheep and goat. To *calcitrans*, donkey was still the preferred animal followed by horse, buffalo, cow, camel, sheep and goat.

The feeding period varies according to temperature conditions. In *calcitrans* it decreased with the increase of temperature. Thus at 30°C., it averaged 7 minutes, while at 21°C., it averaged 15 minutes.

The digestion period also varies according to temperature and the kind of blood. Thus at 30°C., when the adult was fed on man's blood, a female *calcitrans* digested the whole meal in about 14 hours and 36 minutes. At 25°C., the mean digestion period was about 21 hours and 11 minutes. When the adult was fed on citrated calf blood, the period was shortened nearly to about the half.

Studies on the biting cycle have revealed, that in hot months (summer and early autumn), there are two peaks of biting activities, one in the morning, and one in late afternoon, with a marked drop about noon. On the advent of the cold season, the morning peak of *sitiens* was distinctly higher than the afternoon peak, although the reverse is true in hot months. In the colder season of the year (winter) both species have a single peak, about 2 p.m. *S. sitiens* generally displays a greater biting activity than *calcitrans*.

The mechanism of feeding of the two species of *Stomoxys* was also described.

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HISTOPATHOLOGICAL STUDIES ON THE EFFECT OF THE MICROSPORIDIUM *NOSEMA BOMBYCIS* NAEGELI ON THE COTTON LEAF-WORM, *PRODENIA LITURA* F.

(with 9 Text-Figures)

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I. INTRODUCTION

The role of protozoa in destruction of insects in nature is probably much greater than is generally realized. The protozoan spores are less susceptible to changing environmental conditions and are therefore more likely to maintain constant with susceptible hosts and offer a greater promise in use for insect biological control.

The two common methods of transmission of the protozoan diseases of insects are by the way of the mouth and from the female through the eggs to the next generation. Most insects infected with protozoan diseases have very few visible symptoms until shortly before death. Many of the symptoms will of course, depend on the particular tissues affected. Though there is frequently some gross pathology connected with protozoan diseases in insects, most of the change are histopathological.

Infection through ingestion specially occurs in the case of those species which multiply in the cells of the gut epithelium. Transmission through the eggs occurs with *Nosema bombycis* Naegeli. It is the most important microsporidium from the standpoint of insect pathology.

STEINHAUS (1949) reported that many insects have been found experimentally susceptible to infection with *Nosema bombycis* as *Arctia caja* Lin., *Margaro-*

nia pyloalis Wlk., *Chilo simplex* (Butl.) and *Hyphantria cunea* (Dru.). In these insects, the symptoms are for the most part similar to those of pebrine. The insects of Agricultural economic importance that are observed to be infected with the microsporidiosis are the European corn borer, *Pyrausta nubilalis* Hb., and the cabbage butterfly, *Pieris brassicae*. PAILLOT (1928) found larvae of the European corn borer to be infected with a microsporidium which he named *Perezia pyraustae*. The mechanism and the life-cycle of the parasite are essentially similar to those of other microsporidia that attack insects. These investigations are carried out to determine the pathological effect of *Nosema bombycis* Naegeli on the cotton leaf worm, *Prodenia litura* F.

II. REVIEW OF LITERATURE

The microsporidium *Nosema bombycis* has received so much attention of many investigators in the world. NAEGELI (1857) briefly described the pebrine corpuscles in the silk worm as representing some of yeast-like fungus and gave them the name of *Nosema bombycis*. LEBERT and FREY (1858) made important contribution on the pathological significance of the pebrine corpuscles. PASTEUR (1870) published his famous memoir which concerned itself with both pebrine and flacherie. BABIANI (1882) erect a new group microsporidia to include the pebrine organism and related forms. INNES Bey (1888) tried to control the cotton leafworm by the use of the flacherie disease of the silk-worm (GANTES, 1910). The result seemed encouraging under laboratory conditions, but when applied in the field it had a quite negligible effect. STEMPELL (1909) published his work on the life-cycle of the causitive organism of pebrine disease in the silk worm.

The related microsporidium *Nosema apis* had been studied by ZANDER (1911), FANTHAM and PORTER (1912), and KUDO (1921). The microsporidium causes a fatal and dangerous disease to the adult honeybee. STEINHAUS (1949) considered that none of the other classes of protozoa included as many forms pathogenic for insects as does the class sporozoa. The spore stage of this organisms is rather resistant to adverse environmental conditions. Certain species of the sporozoa perhaps offer a greater promise for use in the methods of biological control of insects than do all other groups of protozoa combined.

HASSANIEN (1953) indicated that spores of *Nosema apis* germinate very quickly and the development of *Nosema* disease takes place most rapidly at temperature between 30-35°C. At temperature between 36-39°C the rate of development was reduced, and the life-cycle of the parasite was prolonged. The spores in the bodies of dead bees kept dry at outdoor temperature ceased to be viable after eleven weeks. In the early stages of infection with *Nosema apis* the epithelial cells appear similar to uninfected cells; their size is unchanged and the peritrophic membrane appears normal. At a later stage proliferations of epithelial cells occurs.

In heavily infected portions of the mid gut the secretory epithelium becomes reduced to a disorganised, ill defined, meshwork of broken down cells enclosing masses of schizonts and spores.

III. MATERIAL AND METHODS

The larvae of the cotton leaf worm were bred from egg masses on clover in breeding cages. The larvae were infected at different stages by the microsporidium *Nosema bombycis* Naegeli through the contaminated food. They were fed-with contaminated berseem (Egyptian clover) for one hour, and treated afterwards quite similary as the control larvae.

The infected larvae were examined after few hours from infection and continued subsequently at several intervals. The technique used is studying the fresh material, as fixation and staining may cause morphological changes of the delicate vegetative forms. It is easy to determine the fresh spores of microsporidia, they appear usually oval or pyriform in shape uniform in size and the appearance are highly refractive.

Fixed preparations were made both by films and by sections. The larvae are fixed in BOUIN'S solution for 24 hours. The material is then washed in 70% alcohol 24 hours and transfered to 80% alcohol 12 hours. Dehydrations and embedding then follows employing the following transfers: (1) 90% alcohol for 4 hours; (2) 95% ethyl alcohol for 2 hours; (3) 100% ethanol for 3 hours, three changes; and (4) clover oil overnight.

The oil is removed from tissues by washing in xylene for 15 minutes, xylene paraffin for 15 minutes and paraffin wax for three hours. The material is embedded in a deep watch glass smeared with glycerol. Transverse and longitudinal sections were cut at a thickness of about eight microns. Sections were stained with HEIDENHAIN'S iron haematoxylin and 1% eosin in 90 alchool as counterstain were found satisfactory for this study.

Blood films were prepared according to the technique described by YEAGER et al (1942) and SOLIMAN et al (1958). A drop of the blood obtained by force-pulling one of the legs, is smeared on a slide and were examined for recognising the vegetative stages or fresh spores. Blood films were stained with green malacite or GEIMSA stain for 15 minutes gave satisfactory results in the present study. Illustrations were made with the aid of the camera lucida.

IV. HISTOPATHOLOGICAL EFFECT CAUSED BY *NOSEMA BOMBYCIS* TO BODY TISSUES OF THE COTTON LEAF-WORM

The changes produced by the parasite in the host tissues of larva of the cotton leaf-worm infected with microsporodiosis showed that most histological

changes occured in the mid-gut, Malpighian tubules, fat bodies, trachea and the gonads.

Morphology and life-history of the parasite have been discussed in some detail by STEMPELL (1909). The ripe spore is generally ovoidal, 3-4 microns in length

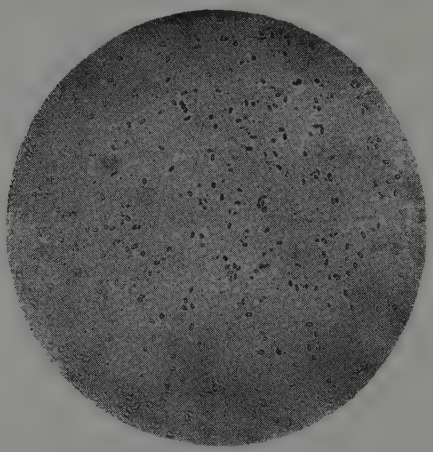

FIG. 1: Spores of *Nosema bombycis* Naegeli.

and 1.5 -2 microns in breadth (Fig. 1). GEIMSA stain easily penetrates the membrane of living spore and the sporoplasm with its two nuclei is quite distinct after few minutes from staining.

The spore is softened under the influence of the digestive juices of the caterpillar and a small amoebola (planont) issues from the spore. Planonts invade the epithelial cells of the mid-gut and Malpighian tubules or into haemocoelic corpuscles. This is followed by shizogamic multiplication shizonts at first being rounded or oval, multiplies rapidly within the cells of the host. STEMPELL distinguished three different modes of multiplication, simple division, multiple division and budding.

Shizonts vary in size and shape according to the amount of space available for their development and number of organism present. The grown uninucleate shizont becomes after a while a sporoplast. The sporoplast begins to differentiate at either pole and cytoplasm becomes girdle like. The nucleus divides into two and one divides into two and one divides again to form three nuclei, the largest being an offspring of the first and one of the first and one of the smaller divides again (Fig. 2).

There are formed four nuclei in the spore, the largest of which remains as nucleus of sporoplasm. Germination of spores was often observed in the mid-gut of the host under the action of the digestive juice.

Mid-gut

A. Normal histology of the mid-gut of the healthy (untreated) larvae

The histology of the mid-gut of the army cotton leaf-worm was described by SOLIMAN et al (1958). It will be seen in Figure 3 that the wall of the healthy mid-gut contains two series of muscle fibres, an outer longitudinal and an inner circular layer. At the base of the epithelial cells a very delicate membrane, the basement

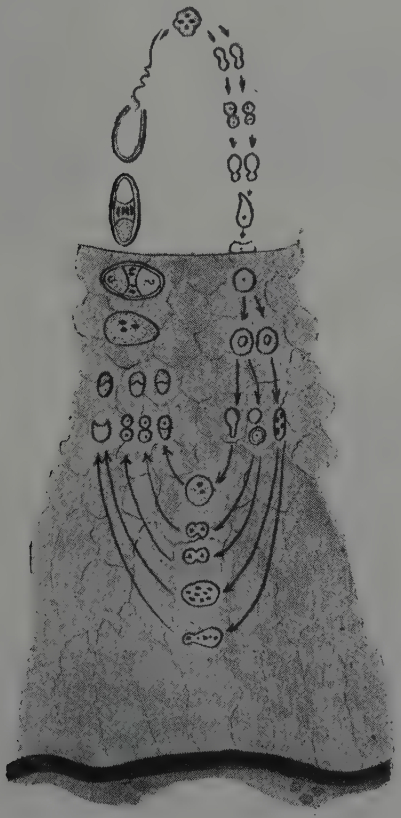

FIG. 2: The life-cycle of *Nosema bombycis* Naegeli.

membrane is found. There are three kinds of cells in the mid-gut epithelium of the larvae. The columnar cells are cylindrical, containing a large nucleus occupying the middle position of the cell. The goblet cells are calyciform in shape (WOKE, 1941) and are seen in great number among the columnar cells. The regenerative

cells are small basal replacement cells scattered along the gut. A striated border is almost universally found on the lumen surface of the mid gut epithelial cells (Fig. 3).

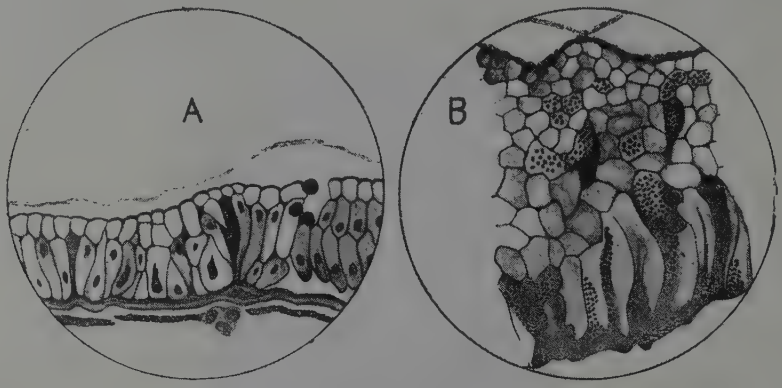

FIG. 3: Part of a transversal section in mid-gut of *Prodenia* (A, healthy larva; B, infected larva), diagrammatically.

B. Histopathological action of microsporodiosis

The changes noticed in the mid-gut of larvae infected with *Nosema bombycis* showed that the first cells to become infected are usually the epithelial cells. In early stages of infestation the epithelial cells appear to be unirfected cells, their size is unchanged and the peritrophic membrance appears normal. At a later stage of infection, proliferation of epithelial cells occurs, and this condition may per-

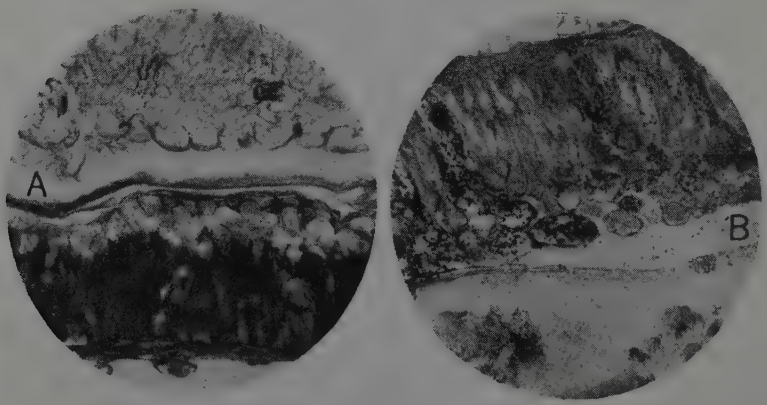

FIG. 4: Part of a transversal section of a mid-gut of *Prodenia* (A, healthy larva; B, infected larva).

haps be explained by delay in discharge of the secretion of these cells into the lumen of the mid-gut (HASSANEIN, 1953). Small cap-like cells are to be observed covering the ends of some epithelial cells. The heavily infected epithelial cells becomes ill defined, disorganised, mesh-work of broken down cells enclosing shizonts and spores. The passage of the spores into the lumen of the mid-gut is accompanied by the breakdown of the walls of the cells and the lumen becomes filled with a mass of ruptured epithelial cells, that have been broken free and are filled with a mass of spores.

The examination of the preparations made in the present investigations indicate that microsporodiosis causes the torn and derangement of the epithelial cells and the destruction of the peritrophic membrane of the mid gut (Fig. 4).

The Malpighian tubules

A. Normal histology

There are three Malpighian tubules running along each side of the mid-gut of the cotton leaf worm (HASSAN et al, 1958), one lying dorsally, the other laterally and the third ventrally. The terminal end of the three Malpighian tubes enter the rectal walls of their anterior parts. The muscles surround the extreme

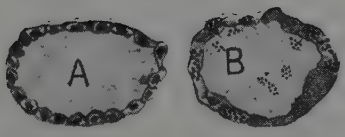

FIG. 5: Transversal section in an Malpighian tube (A, healthy; B, infected).

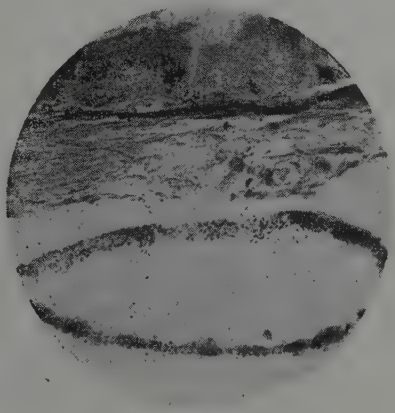

FIG. 6: Transversal section in an infected Malpighian tubule.

proximal portion of the tube at its junction with the gut (PALM, 1946). Each tube is covered with a basement membrane made up of few cells in one layer. In cross-sections (Figs. 5 and 6) it is seen that cells from the wall of the tube surround the central lumen. The cytoplasm of the cells is filled up with pigmented droplets. The structure throughout the whole length of the tube is similar.

B. Histopathological action of the parasite

Examination of preparations of the Malpighian tubules infected with *Nosema bombycis* shows that the parasite attacks the cells of the tubules. The epithelium shows considerable proliferation and masses of the spores invade the cells of the tubule. Infection of the Malpighian tubules undoubtedly affects excretion and it seem highly probable that excretion is seriously retarded with the result that excretory products accumulate in the blood of the larvae and has serious effect on the muscles of the larva (Figs. 5 and 6).

Fat body

A. Normal histology

The fat cells are adherent and the external surface of the cell masses are covered by a delicate membrane sheath. The cytoplasm is homogeneous with a big nuclei. This is in accordance with the description of such structures by several authors (SONDGRASS, 1935; SOLIMAN et al, 1958).

B. Effect of parasitism

The infected fat bodies are usually of a dull white colour. The tissues are soft, watery and easily crushed than the healthy bodies. The fluid that flows from the infected fat bodies, when crushed is full of spores and can be detected microscopically in fresh films. The histological changes caused by infection with *Nosema bombycis*, to the fat body of infected larva is the destruction of the cells, the nuclei are invaded and become granular in appearance. The cytoplasm of the infected cells is full of the parasite in different stages and it can be easily recognised the highly shrinkage of the cytoplasm (Fig. 7).

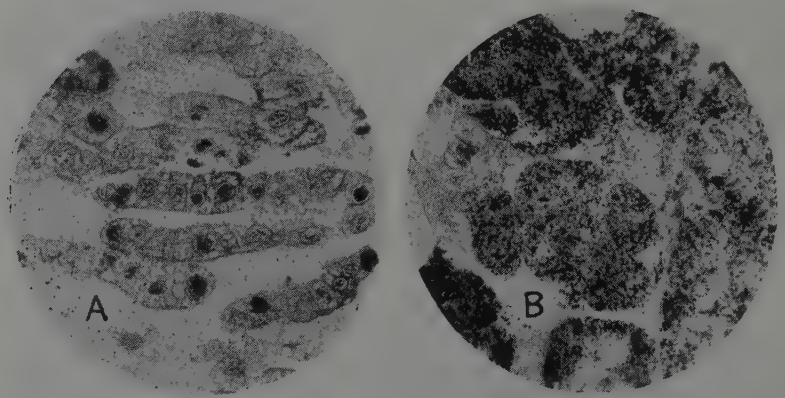

FIG. 7: A, healthy fat bodies; B, infested fat bodies.

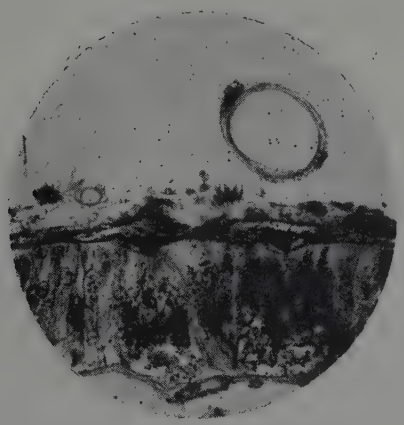

FIG. 8: Transversal section in mid-gut and trachea.

Blood cells

The blood cells of hemocytes include the cells found freely suspended in the hemolymph. LEIBERMAN (1946) considers the blood of all animals to fall into two major types, trephocytes, which are on phagocytes when mature and contain nutritive and lymphocytes, which include hyaline leucocytes, amoebocyte and phagocytes.

YEAGER (1953) studied the hemocytes of the southern army-worm *Prodenia eridania* and classified the insect blood histology into ten classes containing thirty two types. SOLIMAN et al (1958) recorded four groups of blood cells of the cotton leaf-worm in accordance with the finding of CAMERON (1930) and STEINHAUS (1949) in the caterpillars.

The blood cells noticed and examined in the present investigations are the following: (1) plasmotocytes (round, avoid cells with finely vacuolated cytoplasm and punctate nuclei; (2) oenocytes-like cells (oval shape and the nuclei is central), (3) polypodocyte (flat cells with pseudopod-like extensions); (4) leucocytes (small round fusiform cells); (5) cystocyte cells (round, ovoid or irregular cyst-like); (6) lymphocytes spindle shaped or oval with round or oval nuclei.

This is in agreement with the finding of YEAGER (1954).

The infection with the microsporidiosis causes a change in the form of the blood cells and the hemocytes of the infested larva show marked pathological changes. The infection produce desintegration of the blood cells, the disappearance of the vacuoles in the plasmotocyte cells and the degeneration of the cytoplasm.

The gonads

The gonads in the mature larva occur in the dorsal side of the fifth abdominal segment. The male gonad is about 2-5 mm. in length and 1.5 mm. in width,

and the female gonad is about 0-7 mm in length. Microscopical observations show that the gonads are divided into compartments which lead to the ovarioles of the ovary and the sperm tubes of the testis.

The gonads of the infected larvae with the microsporidium *Nosema bombycis* differ histologically from the healthy. The germ cells show the symptoms of infection and the infected cells show considerable cellular alternation as the result

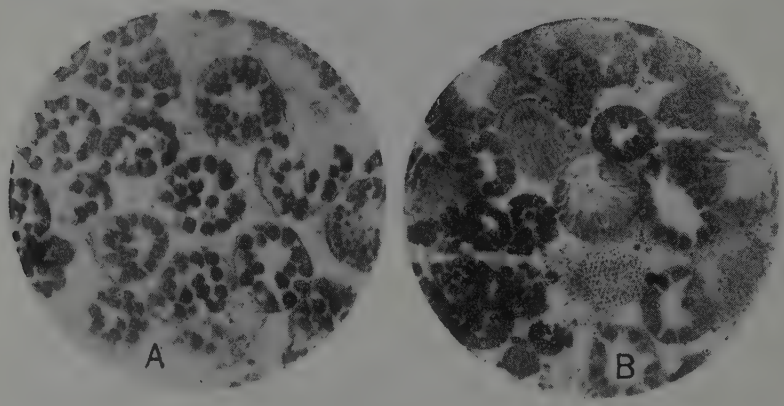

FIG. 9: A, healthy gonads; B, infested gonads.

of parasitism. The cytoplasm is heavily infected and the nuclei is largely injured. Figure 8 shows transverse sections in the normal and infected gonads of the cotton leaf-worm.

SUMMARY

Nosema bombycis Naegeli is the most important microsporidium from the stand point of insect pathology. The present investigations were carried out to determine the effect of *Nosema bombycis* Naegeli on the cotton leaf-worm *Prodenia litura* F.

The changes produced by the parasite in the host tissues of larvae of the cotton leaf-worm infected with microsporidiosis showed that most histopathological changes occured in the mid-gut, Malpighian tubules, fat bodies, blood cells and the gonads.

(1) The infected epithelial cells of the mid-gut become ill defined, disorganised and the passage of the spores into the lumen is accompanied by the breakdown of the walls of the cells. The infection causes the derangement of the epithelial cells and the destruction of the peritrophic membrane of the mid-gut.

(2) The parasite attacks the cells of the Malpighian tubules and the epithelium shows considerable proliferation and a decrease in the lumen.

(3) The infected fat bodies are of a dull white colour. The cytoplasm of the infected cells is full of the parasite in different stages. The tissues of the infected cells are watery and easily crushed.

(4) The infection with the microsporidiosis causes a change in the form of the blood cell and the hemocytes of the infected larva show marked pathological changes.

(5) The infected gonads differ histologically from the healthy ones. Inside the germarium area the vegetative cells and spores of the microsporidia show the symptoms of infection.

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ON A SEXUAL DIMORPHISM IN THE OLFACTORY LOBE OF THE MIGRATORY LOCUST, *LOCUSTA MIGRATORIA MIGRATORIOIDES* (R.F.)

[*Orthoptera* : *Acrididae*]

(with 1 Text-Figure)

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I. INTRODUCTION

The fundamental structures of the olfactory lobe in insects are the antennary glomeruli. It is well known that these glomeruli are nothing but a differentiated field of the neuropil of the deutocerebrum. The tissue of the antennary glomeruli is constructed mainly of the terminal ramifications of the fibres of the sensory antennary nerve, which come from certain sensory cells located under the sensory pits of the antenna. This leads many authors (e.g. JAWLOWSKI, 1948) to believe that the antennary glomeruli are the main centre of reception of the sense of smell in insects.

While the antennary glomeruli of lower insects such as cockroaches lay together in a compact mass, they are found in other insects with highly developed olfactory lobes (e.g. butterflies) to be arranged in definite groups. A sexual dimorphism in the olfactory lobe was anyhow rarely observed among the Orthoptera.

Males and females required for the present study were dissected carefully with the aid of fine glass-needles and any damage in the sensory antennary nerve was avoided. The detached parts of the brain of both sexes were fixed in a 10% formol-solution and stained with MAYER'S haematoxylin. This was found quite satisfactory to differentiate the various structures of the olfactory lobe.

The author wishes to express his sincere thanks to Prof. Dr. M. HAFEZ, Head of the Entomology Department (Cairo University) for enabling him to ac-

complish his researches in Munich through extending his study-leave. Many thanks are due to Mr. A. Alfieri, Secretary General of the Entomological Society of Egypt, for his help in publishing this work in the Bulletin of the Society.

II. STRUCTURE OF THE OLFACTORY LOBE

(Fig. 1)

The olfactory lobes of *Locusta* are carried by the deutocerebrum as two distinct swellings on both sides. Each lobe consists of an external layer of nerve-cells which surrounds a spherical mass of fibrous tissue, the neuropil. The types of the nerve-cells, their arrangement around the olfactory lobe and the course of their nerve-fibres will be dealt with in a later publication. In the present work, however, only one type of nerve-cells is of special interest, namely the small globulous cells (gl), which lie in direct connection with the antennary glomeruli. These cells are arranged in 2 groups which are located rather deep in the lateral and median zones of the nerve-cell-layer. The fibres of these cells aggregate in 2 bundles which penetrate the neuropil and end in the centre of the olfactory lobe (ZN).

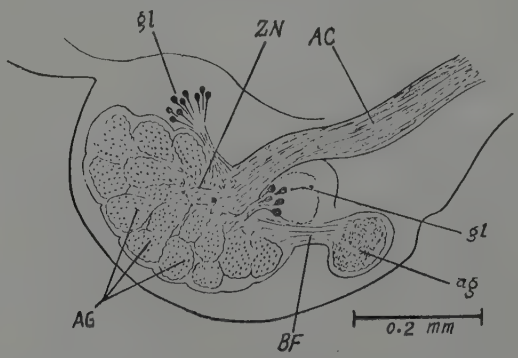

Fig. 1: Transverse section through the olfactory lobe of male *Locusta migratoria migratorioides* (*AC*, antennary commissure; *AG*, antennary glomeruli; *ag*, additional aggregation of antennary glomeruli; *BF*, bundle of fibres; *gl*, globulous cells; *ZN*, central zone of the neuropil).

The antennary glomeruli of both sexes (AG) occupy the neuropil almost totally. They consist of fine aggregations of fibres in the form of a "hollow" hemisphere surrounding the central zone of the neuropil, where the fibres of the globulous cells (gl) end. The glomeruli are arranged in definite groups of which I could count about 15 groups in transverse sections passing through the central region. In the male there is an additional aggregation of glomeruli (ag) lying in the median territory of the olfactory lobe, i.e. towards the middle line of the deutocerebrum.

This aggregation of glomeruli is connected with the central zone through a distinct bundle of fibres (BF). This fact is of particular significance, because this fibrous zone of the neuropil gives origin to the antennary commissure (AC) which joins the olfactory lobes of both sides with each other.

Such a sexual dimorphism in the olfactory lobe seams to be characteristic of *Locusta*, as it was not observed by JAWLOWSKI (1954) in many other species of Saltatoria, e.g. *Locusta viridissima*, *Gryllus campestris* and *Gryllotalpa vulgaris*. A similar structure in the olfactory lobe was found, however, in the males of *Periplaneta* and *Apis* (JAWLOWSKI, 1948) and in some butterflies, e.g. *Bombyx* and *Lasciocampa* (BRETSCHNEIDER, 1924). These authors suggest that such a structure in the male insects ought to have a particular sensory function (probably the reception of certain odours sent by the female before mating). Such a suggestion needs, however, the support of physiological evidence.

III. SUMMARY

The olfactory lobe of the male of *Locusta migratoria migratorioides* includes an additional aggregation of antennary glomeruli, which was not observed by JAWLOWSKI (1954) in many other Saltatoria.

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PERSISTENCE OF FOSFERNO (1) AND THIMET (2) TOXICITIES IN COTTON SEEDLINGS AND THEIR EFFECT ON GERMINATION AND GROWTH OF SEEDLINGS

(with 5 Tables)

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and Dr. M. A. BESHR, *Agronomy Department*,
College of Agriculture, Alexandria University.

Many of the organic phosphates, to which Parathion (an active ingredient in Fosferno) pertains, are known to have a systemic effect and promote growth of seedlings.

Tsi Chao-Seng (1950) found that soaking broad beans (average weight 2.57 gms.) for 24 hours in 0.5% aqueous solution of schradan prevented the establishment of *Macrosiphum pisi* and red spider on the seedlings for fifty days. In other experiments the seeds were allowed to dry after soaking but at subsequent planting they retained their insecticidal properties. Cotton seeds soaked in 2, 1, and 0.5% solution of the insecticide became toxic to *A. rhamni* and *Tetranychus* sp. for 7 weeks. It was also stated that in general, the protecting effect varied with the weight of the seed. Several kinds of beans and nasturtium acquired protection by soaking.

Ivy (1951) reported that cotton seedlings were rendered toxic to aphids and mites for six weeks if seeds had been soaked for two hours in solutions containing as low as 0.5% schradan.

Data on phytotoxicity and stimulative effect of organic phosphates on plant growth were published time and again by several authors.

Tsi (1950) found that growth of cotton plants up to the 7th. week was greatly promoted if the seeds were soaked in 2, 1, and 0.5% schradan solution. The promotion of growth was graded with the graded decrease in concentration of insecticide. Germination rate of pea seeds was greatly decreased when they were soaked

(1) Acetic commercial preparation of Parathion.
(2) An American cyanide product formed.

in 2% aqueous solution of schradan, while the 1% aqueous solution has no effect. *Nasturtium* seeds could stand up to 5% schradan without ill effect.

HALL (1951) reported that low concentrations of organophosphorous insecticides induce better growth in carnation and tomato plants.

CASIDA et al. (1952) found that low concentrations of schradan increased the dry weight and moisture content of pea plants. However, they gave no figures in support of their findings.

Theories were forwarded to throw light on the favorable effect of organic phosphates on plants. To that effect several authors had devoted their work.

WOLFENBARGER (1948) ascribed the stimulative effect of schradan to its available nutritive phosphorous. The phosphate bond energy p-o-p was the cause of better growth induced by the organophosphorous insecticides as OESPER (1950) stated. CASIDA et al. (1952) thought that the favorable effect of schradan on pea is due to its effect on some enzymes as phosphatase. HACSKAYLO (1955) stated that the role of schradan as a supplemental source of P must be minor because when sufficient quantities of P are available in the nutrient solution, the additional amounts as supplied by minute quantities of schradan (10 p.p.m.) are not sufficient to account for the observed stimulation of growth. Neither was there any significant difference in the total P of the plants of the two treatments (0 and 10 p.p.m.).

However, marginal leaf burning characterizing the P deficient plants was not evident in those plants grown in phosphorous deficient water culture and receiving schradan in low concentrations. The stimulative effect of schradan on growth was attributed to increase in chloroplasts. Logically, accelerated photosynthesis follows and corresponding increase in carbohydrates which results in increased dry weight of plants. Those phenomena were observed in cotton plants treated with 10 and 100 p.p.m. of schradan.

Parathion, which established its virtue as contact and stomach poison and as an ovicide, has a partial systemic effect. It is the purpose of this paper to find out the right concentration of Parathion (marketed by ICI under the name Fosferno) which protects cotton seedlings grown from Fosferno treated seeds against *Aphis gossypii* (Glov.). Concentrations of Parathion used for testing persistence of its toxicity is limited by its phytotoxicity and effect on germination. A lot of work was expended to reveal its effect on germination and growth of seedling.

Similar work follows on cotton seeds to study the systemic toxicity of Thimet which outgrew Parathion in importance in that respect.

INSECT TOXICITY TESTS

Cotton seeds "Karnak variety" were soaked for 24 hours in Fosferno aqueous solutions. Concentrations used, based on Parathion content were 0.01, 0.02,

0.03, 0.04, 0.05, and 0.1%. Seeds were sampled and soaked in the above concentrations at the rate of 100 seeds per 100 cc. of solutions, and were then planted in flower pots. Seedlings for aphicidal tests were carefully pulled out with the least damage to rootlets after watering the pots. Vials 1 × 3" with drilled corks were used to accomodate the seedlings. Two seedlings were put in each vial which was filled with water and the cork holes were filled with cotton wool around the seedlings' plumules to give them good support. In that way it was possible to keep seedlings for a week. Vials were placed in tall 250 cc. beakers thoroughly cleaned and then 20-25 cotton aphids were transferred by a brush to the seedlings and were equally distributed among cotyledons. Beakers were then covered with muslin and were put in trays filled with water to protect them against ants. Counts on living and dead aphids were made 48 hours later. Dead aphids drop to the bottom of beakers and appear as greenish yellow or brown spots. Aphicidal tests started one day after emergence of seedlings (4th day after planting seeds). Cotton seedlings were grown outdors in July-September and aphicidal tests were made at room temperature.

Persistence of toxicity was tested on seedlings 4, 5 and 6 days old (counted from day of planting) until Parathion effect disappeared. However, with the 0.1% aqueous solution toxicity tests were continued up to the 13th. day because toxicity lasted in the seedling that long. Nine experiments with 20-25 aphids of different ages for each, were run for each Fosferno concentration (except the 0.1%). Three experiments for each age of seedling were done and their results are averaged in Table I.

TABLE I

Aphicidal effect of Fosferno on seedlings of treated cotton seeds. Toxicity is expressed in percentage kill.

Age of seedlings in days	Concentration percentage						Control
	0.01	0.02	0.03	0.04	0.05	1.0	
	Kill percentage						
4	4.4	10.0	80.9	100.0	95.0	100.0	4.9
5	3.3	10.7	14.0	12.3	8.4	84.4	6.7
6	1.5	6.7	2.1	2.4	5.4	94.0	1.6
7	—	—	—	—	—	54.0	0.0
9	—	—	—	—	—	68.0	2.5
10	—	—	—	—	—	24.0	0.0
13	—	—	—	—	—	12.0	5.8

The above Table is self evident and shows that soaking seeds in 0.01% and 0.02% solutions did not protect the seedlings any length of time after emergence.

Toxicity was acquired on the fourth day after planting, then subsided on the fifth when seeds had been soaked in 0.03, 0.04 and 0.05%. However, with 0.1%, toxicity lasted for thirteen days but was considerably decreased on the seventh day.

Seedlings grown from seeds treated with concentrations higher than 0.1% were not tested for toxicity because such concentrations decrease germination to a great extent (Table II).

THIMET TOXICITY (3)

Thimet established its fame in America as the most efficient of systemic insecticides for cotton seedling protection. HACSKAYLO and CLARK (1957) found that cotton seeds treated with Thimet powder at the rate of 4 (4) pounds per 100 pounds of seeds continued to be toxic up to 47 days and toxicity started to decline on the fifty-seventh day. They showed that Pima 5-1 seedlings absorb Thimet in quantities which were comparable to those taken up by Deltapine as measured by insect bio-assay. Their results may not hold for Egyptian cotton varieties as they worked on different varieties and delinted the seeds with sulfuric acid before mixing them with Thimet.

TABLE II

Toxicity of seedlings of cotton seeds treated with Thimet

Age of seedlings in days	Concentration percentage						Control
	0.001	0.003	0.006	0.012	0.025	0.05	
	Kill percentage						
4	—	92	95	100	100	100	0
5	30	—	—	—	100	100	5
7	5	100	100	81	—	—	0
9	—	52	98	98	—	—	4
12	—	10	90	100	—	—	0
15	—	8	44	69	90	100	0
16	—	—	—	—	68	100	0
20	—	—	50	40	—	—	5
23	—	—	—	—	60	93	0
31	—	—	—	—	7	50	4

The procedure of testing toxicity of Thimet in cotton seedlings differs in minor particulars from the procedure of testing Fosferno. Differences lie in concen-

(3) Thimet 44-D contained 44% of the active ingredient 0.0 diethyl -S- (ethyl thiomethyl) phosphodithioate (88% pure) and 2% of methyl cellulose and the rest was carbon powder. That formulation was manufactured by the AMERICAN CYNAMIDE Co. and provided by HOMSY Brothers.

(4) Concentration of active ingredient in the powder used for seed treatment was not given in their publication.

trations used and the number of replicates within each treatment. Each of the experiments tabulated in Table II was repeated only twice.

Some aphids were able to live on 4 and 5 days old seedlings of seeds treated with 0.001, 0.003, 0.006% in spite of the high percentage kill with the last concentration. That percentage started to decrease rapidly on the 5th. and 7th. days with 0.001%, on the 9th. day with 0.003%, on the 12th. day with 0.006%, on the 15th. for 0.012%, on the 15th. for 0.025%, and on the 23rd. for 0.05%.

The latter concentration, which proved to be the best of all concentrations used, is much less than the concentration recommended by the manufacturer (1 kilo per 60 kilos seeds) and that is equivalent to 7 grams of active ingredient per kilo of the Thimet powder while the concentration of 0.05% is equivalent to 0.4% gram of the active ingredient per liter of Thimet solution.

GERMINATION TESTS

A. Fosferno

Soaked seeds were spread over blotting papers in a germinator at 23°C. On the 3rd. and 5th. days, germination rates were determined, and on the 5th. day radicals' lengths were measured in 100 seedlings in each treatment.

Preliminary experiments on germination using 1, 0.5 and 0.1% solutions of Parathion (Fosferno) formed the starting point of this work. Depression of germination and stunting of radicals were very obvious with such concentrations as Table III shows. The result were encouraging when lower concentrations were used (Tables III and IV).

TABLE III

Effect of Fosferno on germination of cotton seed "Karnak" variety.

Concentration percentage .	0.001	0.005	0.01	0.05	0.1*	0.5*	1.0*	Control
Germination percentage ...	92.2	89.5	87.2	73.5	9.0	6.0	0.0	91.7

The figures with the asterisks were obtained from preliminary experiments carried on 200 seeds for each concentration. Each of the other figures was the average of four tests; 300 seeds were used per test.

The F test showed that there was a highly significant difference among treatments. The L.S.D. values at both levels of 0.05 and 0.01 showed clearly that there was no significant difference between the control and 0.001 or 0.005% treatments. However, there was an apparent increase of radical length with both concentrations over the control. The differences between the concentrations 0.01 or

TABLE IV

*Effect of Fosferno on radical length of cotton seedlings**
Length of radicals is in millimetres

Experiments	Treatments (Concentrations)				Control
	0.001	0.005	0.01	0.05%	
I.	31.3	35.8	31.0	17.0	32.3
II.	40.2	32.7	30.4	19.7	35.8
III.	34.9	33.9	28.7	19.9	36.9
IV.	41.3	41.1	29.6	23.1	36.9
Totals	147.7	143.5	119.7	79.7	141.9
Means	36.9	35.9	29.9	19.9	35.5

* 100 radicals were used in each concentration.
L.S.D. at 0.05 level is 3.92
L.S.D. at 0.01 level is 5.51

0.05 and the control were highly significant and indicated that both concentrations were highly depressive.

Fosferno at 0.05% decreased radicals' growth, germination percentage of cotton seeds and protected seedlings for one day only after emergence. For 0.1% Parathion, different degrees of toxicity lasted for 13 days but germination rate was shockingly low.

The above effects cannot be ascribed to Parathion only as constituents of Fosferno other than Parathion may induce its ill effects on germination, growth and perhaps impair its toxicity in seedlings. Some of these constituents are the following isomers of Parathion which are produced during its manufacture: O,S-diethyl O-p-nitrophenyl thiophosphate, para-oxon, and S-ethyl O,O,-bis-(p-nitrophenyl) thiophosphate. In aqueous solution Parathion is also slowly hydrolyzed to form p-nitrophenol and diethyl ortho-thiophosphoric acid (METCALF, 1955). Any of the above compounds may have its particular effects which influence the final results of seed treatments by Fosferno.

B. Thimet

HACSHAYLO and CLARK (1957) stated that seed treatment with Thimet encouraged germination of Pima S-1 and Deltapine cotton seeds. It manifested its effect on the first variety more obviously than on the second.

The like of the experiments carried out before on cotton seeds treated with Fosferno to verify its effect on rate of germination and radical length were done with Thimet instead. In germination tests four hundred seeds were used for each con-

centration and figures indicating radical length are each average of 100 radicals treated with each of the concentrations.

TABLE V

Effect of Thimet on germination of cotton seeds and radical length

Concentration	Germination percentage	Average radical length in millimetres
0.1	97.5	48.6
0.05	98.0	48.8
0.025	95.8	46.6
0.012	97.25	50.7
0.006	96.25	46.6
Untreated	97.0	46.26

, Data in Table V indicate slight increase in germination in radical length due to treatment with 0.1 and 0.05%. The latter concentration imparted considerable toxicity to seedlings and lasted to the twenty third day. However, that period is not considered long enough to protect cotton against thrips. It usually ranges cotton for two months in Alexandria.

SUMMARY

Fosferno and Thimet were evaluated as cotton seedling's protectors against *A. gossypii* Glov. Their effects on germination and radical growth were implied in their evaluation.

Treatment of seeds with 0.01 and 0.02% Parathion gave no protection to seedlings grown therefiom against aphids. Concentrations of 0.03, 0.04 and 0.05% Parathion were effective in controlling aphids on cotton seedlings for one day only after emergence. Treatment of seeds with a 0.1% Parathion protected seedlings in varying degrees over a period of thirteen days.

Germination tests showed that higher concentrations of Parathion, 0.05 and 0.01, were harmful although lower concentrations, 0.001 and 0.005 did not have any depressive effect. On the other hand, lower concentrations showed some increase in radical length as compared to the control. A former concentration of 0.001 slithtly increased germination rate.

Thimet gave better results than Fosferno, while toxicity of seedlings to aphids lasted for 23 days with 0.05% Thimet it lasted for one day only after emergence with the same concentration of Forferno. Besides, it did not have any ill effect on germination rate and radical length. Actually, Thimet concentrations higher than 0.05% increased germination ratio and radical length contrary to the same concentrations of Fosferno.

ACKNOWLEDGMENT

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EMBLÉTHIS OBLONGUS, NOV. SPEC.

[*Hemiptera-Heteroptera*: *Lygaeidae*]

(mit 11 Abbildungen)

von EDUARD WAGNER, Hamburg.

Gestalt (Fig. 1), mittelgross, schlank, nach hinten etwas verbreitert; die breiteste Stelle liegt in Höhe der Clavusspitze. Gelbbraun, unregelmässig mit feinen, schwarzen Punkten bedeckt und ausserdem schwarz gescheckt. Kahl, Kopf und Extremitäten mit einzelnen Borsten. Makropter.

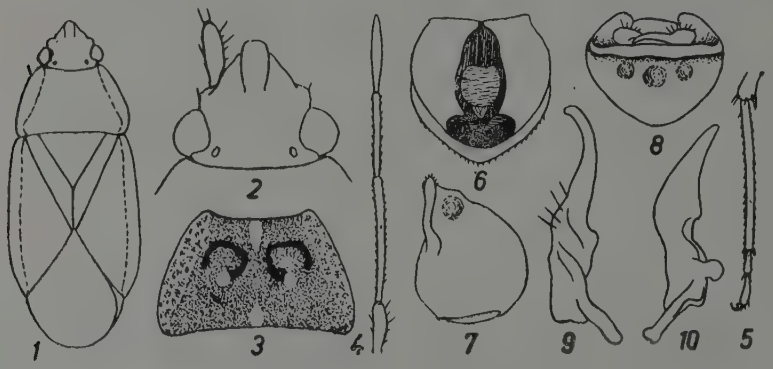
Kopf (Fig. 2) verhältnismässig lang und spitz, aber dorh breiter als lang. Scheitel bei Männchen+Weibchen etwa 3 × so breit wie das kleine Auge. Fühlerhöcker vorstehend, mit einer kleinen Borste. Fühler gelbbraun, mit feinen, kurzen, schwarzen Borsten bedeckt; 1. Glied ausserdem mit einigen längeren Borsten, 0,6 × so lang wie der Scheitel breit ist, die Spitze des Kopfes deutlich überragend; 2. Glied lang, schlank, leicht gekrümmt, so lang wie der Kopf breit ist und 1,55 × so lang wie das 3. Glied (Fig. 4), das 4. Glied kaum länger als das 3., spindelförmig und ohne Borsten.

Pronotum (Fig. 3) trapezförmig, nicht ganz doppelt so breit wie lang, der ausgebreitete Rand ist etwas breiter als das Auge und doppelt so breit wie die Stirnschwiele dick ist, unregelmässig mit kleineren Gruppen von etwas grösseren, schwarzen Punkten bedeckt. Um die Schwielen liegt ein hinten offener schwarzer Ring. In der Mitte des Vorder- und Hinterrandes ein heller Längsfleck (Fig. 3) und ebenso hinter jeder Schwiele ein solcher Fleck. Scutellum etwa so lang wie breit, deutlich, kürzer als das Pronotum, die Spitze und 4 einen Bogen bildende Flecke im vorderen Teil schwarz, hinterer Teil mit heller Mittellinie. Halbdecken gescheckt, der ausgebreitete Rand so breit wie beim Pronotum, mit unregelmässigen schwarzen Flecken. Membran milchweiss, die Adern und einige unregelmässige Flecke braun. Bisweilen finden sich in den braunen Flecken kreisrunde helle Flecke.

Unterseite schwarz. Hinterränder und Innenwinkel der Bruststücke weisslich, schwarz punktiert. Beine gelbbraun, mit feinen schwarzen Borsten; die Schienen ausserdem mit schwarzen Dornen. Unterseite der Vorderschenkel mit einer Reihe von 7 kräftigen Zähnen, daneben eine Reihe feiner Borsten. Füsse sehr lang

und schlank. An den Hintertarsen ist das 1. Glied etwa 2,9 × so lang wie das 2. und 3. zusammen (Fig. 5). Rostrum schwarz, bis zwischen die Mittelhüften reichend.

Genitalsegment des Männchen (Fig. 6-8) herzförmig. distal mit kräftiger, dicker Leiste, die mit kurzen Borsten bedeckt ist. Diese Leiste geht allmählich in



Emblethis oblongus nov. spec., Männchen:

1 = Gestalt (9×) 2 = Kopf von oben (22.5×) 3 = Pronotum von oben (15.8×) 4 = Fühler (18×) 5 = Hinterfuss (22.5) 6 = Genitalsegment von oben (31.5×) 7 = dasselbe seitlich 31.5×) 8 = dasselbe von hinten (31.5×) 9 = Paramer von der Seite (84×) 10 = derselbe von oben (84×).

die Seiten über und ist überall von etwa der gleichen Breite. Genitalöffnung zweiteilig. Der vordere Teil längsgerichtet (Fig. 6), seine Ränder fast glatt; der hintere Teil oval und querliegend; zwischen beiden Teilen eine zahnartig vorspringende Ecke. Seitlich gesehen (Fig. 7) ist das Segment etwas niedriger als lang, dorsal fast eben, distal aber stark gewölbt. Von hinten gesehen (Fig. 8) ist es oben flach, doch erscheinen die Flächen neben der Genitalöffnung stark gewölbt und hell gefärbt. Am distalen Ende zeigt das Segment unterhalb der Leiste 3 Grübchen, von denen das mittlere am deutlichsten ist.

Parameren (Fig. 9+10) lang und schlank, distaler Teil (Hypophysis) messerartig, von oben gesehen breit und leicht gekrümmt, seitlich gesehen (Fig. 9) und stärker gekrümmt. In der Mitte des Paramerenkörpers findet sich ein undeutlicher Höcker mit 3 order 4 Borsten.

Länge: Männchen = 5.2-5.5 mm, Weibchen = 6.1-6.9 mm.

E. oblongus n. sp. fällt auf durch die schlanke Gestalt (Fig. 1) und die ungewöhnlich langen und schlanken Füsse. Auch die Fühler sind verhältnismässig lang und erreichen die Hälfte der Länge des Tieres. Am nächsten steht er ohne Zweifel *E. gracilicornis* Put. Da diese Art gleichfalls aus Arabien beschrieben wurde und in vielen Merkmalen mit der hier vorliegenden Art übereinstimmt, bestand der Ver-

dacht, dass beide identisch sein könnten. Da sich aber doch eine Reihe von Merkmalen fand, in denen sich beide unterscheiden, müssen beide als getrennte Arten gewertet werden. Bei *E. gracilicornis* Put. ist die Gestalt noch schlanker, das Pronotum ist beträchtlich länger und in der Mitte so lang wei am Hinterrande breit, der Kopf ist etwas länger als breit, das Scutellum ist so lang wie das Pronotum, die Fühler sind noch länger und schlanker, ihr 1. Glied überragt jedoch die Spitze des Kopfes nicht nach vorn, während das 2. Glied deutlich länger ist als der Kopf breit ist und etwa so lang wie das 3. und 4. zusammen. *E. angustus* Mont. ist ebenfalls von schlanker Gestalt, ist aber deutlich grösser, hat grössere Augen, der Scheitel ist 2.65-2.70 × so breit wie das Auge, der Kopf ist kürzerund die Fühler sind kürzer und dicker. Auch *E. denticollis* Horv. hat eine schlanke Gestalt, gehört aber zur Gruppe der Arten mit sehr kurzem 1. Glied der Hintertarsen. Alle übrigen mir bekannten Arten haben entweder eine breitere, ovale Gestalt oder das 1. Glied der Hintertarsen ist weit kürzer.

Ich untersuchte 5 Männchen und 18 Weibchen aus Saudi-Arabien: El Riyadh, April 1956, 2 Männchen, 4 Weibchen, und Juni 1958, 3 Männchen, 14 Weibchen (sämtlich E. DIEHL leg.).

Holotypus und Allotypoid in meiner Sammlung, Paratypoide ebenda und in der Sammlung H. ECKERLEIN, Coburg.

Zu besonderem Dank verpflichtet bin ich Herrn Dr. H. ECKERLEIN, Coburg, der mir das Material zuleitete und Herrn G. SEIDENSTÜCKER, Eichstätt, der mir mit Rat und Literatur aushalf.

COLEOPHORIDEN AUS IRAN UND IRAQ DER AUSBEUTE E. P. WILTSHIRE

[*Lepidoptera*: *Coleophoridae*]

(mit 53 Abbildungen)

von S. TOLL (Katowice)

Die Microlepidopterenausbeute des Konsuls E. P. WILTSHIRE aus Iran und Iraq, die ein sehr umfangreiches Material aller Familien enthält, wurde seit Jahren Herrn Dr. H. G. AMSEL, Karlsruhe, zur Bearbeitung übergeben, der über dieses Material mehrere Arbeiten veröffentlichte und der noch weitere Arbeiten hierüber veröffentlichen wird. Soweit in diesen Ausbeuten Coleophoriden vorhanden waren, hatte Herr Dr. AMSEL die Vertreter dieser Gattung mir zur Determination übersandt, worüber im folgenden berichtet werden soll.

Coleophora zernyi Toll.

Iraq, Haj Omran, Rayat, 5000-6000 ft., 2.-13. VI. 1956 (2 Exemplare). Diese Art gehört in die larvipare Gruppe der *C. leucapennella* Hb.

C. alcyonipennella Koll.

Iraq, Haj Omran, Rayat, 5000-6000 ft., 2.-13. VI. 1956.

C. anatipennella Hbn.

Iran, Alvand, 7000 ft., 14.VI.1938, [Prov. Hamadan], Genital-Präparat Nr. 38.

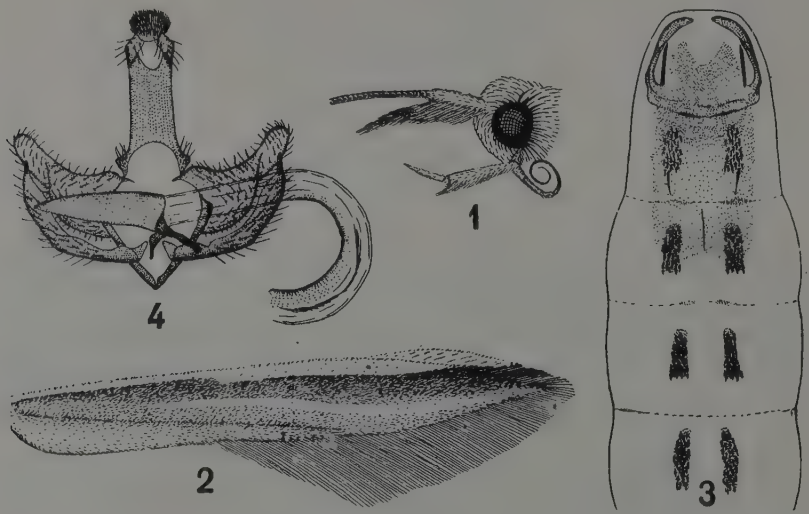
Die nachstehenden 8 Arten gehören in die *vibicella*-Gruppe.

C. iranella, n. sp.

Die Art steht genitaliter der *C. gallipennella* Hbn. sehr nahe.

Kopf (Fig. 1) und Thorax weiss mit kaum wahrnehmbarem bräunlichem Anflug. Basalglied der Antennen gelblichweiss, der Haarschuppenpinsel am Basalglied gelblichweiss, Flagellum weiss. Palpen gelblichweiss, Mittelglied 1 1/2 mal so lang, wie der Augendurchmesser, Endbusch bis 1/3 der Endgliedlänge reichend, Endglied 2/3 so lang, wie das Mittelglied.

Vorderflügel (Fig. 2) hell gelblichgrau, Keilstrieme braun, nicht sehr scharf begrenzt. Die weissen Striemen ohne Glanz. Costalstrieme beginnt an der Flügelbasis schmal. Etwas vor der Mitte der Costa erweitert sie sich plötzlich durch eine Stufe und verläuft doppelt so breit in die Fransen. Medianstrieme beginnt bei 1/3 der Flügellänge und erlischt vor dem Apex. Sie ist schmal und etwas geschwungen. Dorsalstrieme breit, undeutlich begrenzt. Fransen an der Costa weiss, um den Apex bräunlichgrau, am Saum grau. Spannweite 23 mm.



Coleophora iranella, n. sp.:
FIG. 1: Kopf. — FIG. 2: Vorderflügel. — FIG. 3: Erste Sternite. — FIG. 4: Männlicher Genitalapparat.

Querleiste des Verstärkungssystems auf dem I. Sternit (Fig. 3) mit 4 mal unterbrochener schmaler Falte am proximalen Rande. Die Falte am distalen Rande ist in der Mitte verschmälert. Sternitenscheiben des I. Paares ohne Dornen. Die Scheiben des III. und IV. Paares 2 1/2 mal, die des V. Paares 4 mal länger als breit.

Männlicher Genitalapparat (Fig. 4). Tegumendach schmal, Valve relativ kurz. Der Fortsatz am caudalen Ende des Sacculus ziemlich kurz. Aedoeagus lang, Coecum lang und schmal. Cornuti zahlreich, kurz.

Holotypus (Männchen), Nord-Iran, Elburs-Gebirge, Lar-Tal, 8000 ft., 5.-13. VII. 1939.

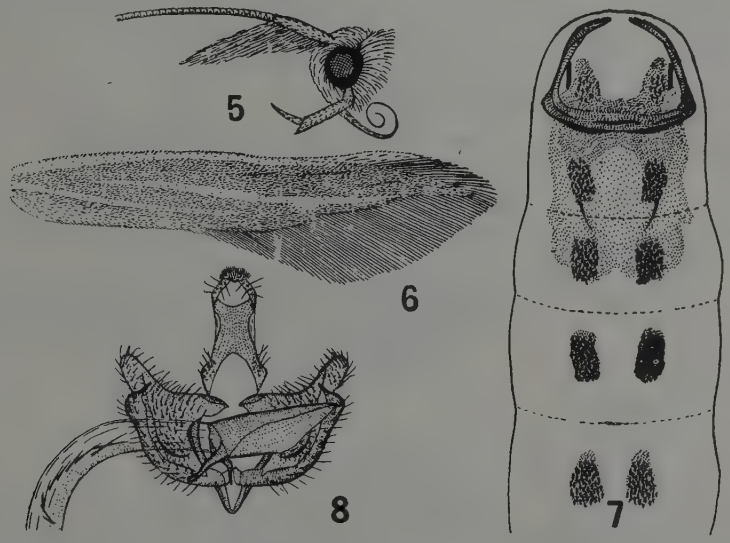
Das Weibchen ist unbekannt.

C. wiltshirei, n. sp.

Diese neue Art ist nahe mit *C. stramentella* Zell. verwandt.

Kopf (Fig. 5) und Thorax weiss, Antennen weiss, Haarschuppenpinsel des Basalglieds gelblichweiss. Palpen hell gelblichweiss, Mittelglied mit kurzem Endbusch, es ist wenig länger als der Augendurchmesser. Endglied etwas kürzer als das Mittelglied.

Vorderflügel (Fig. 6) gelb, Striemen schmal, schwach glänzend. Costalstrieme in ihrer ganzen Länge an die Costa angelehnt. Sie verliert sich in den Fransen. Medianstrieme leicht geschwungen; sie beginnt bei 1/6 der Flügellänge und läuft zum Apex. Analstrieme erreicht den Saum nicht. Dorsalstrieme sehr kurz. Costalfransen weiss, um den Apex gelb, am Saum grau. Spannweite 18 mm.



Coleophora wiltshirei, n. sp.:
FIG. 5: Kopf.—FIG. 6: Vorderflügel.—FIG. 7: I. Erste Sternite.—FIG. 8: Männlicher Genitalapparat.

Querleiste des Verstärkungssystems auf dem I. Sternite (Fig. 7) mit zweimal unterbrochener Falte am proximalen Rande. Distalrand mit breiter, in der Mitte unterbrochener Falte. Sternitenscheiben des I. Paares sehr spärlich mit Dornen besetzt, die des III.-V. Paares $1^1/_2$ mal länger als breit.

Männlicher Genitalapparat (Fig. 8). Tegumendach relativ schmal, Valve kurz, am Cucullus nicht erweitert, Valvula gut abgesetzt, Ventralrand des Sacculus gleichmässig gebogen. Dorsocaudale Ecke in einen starken, nach einwärts geneigten, stumpfen Zahn ausgezogen. Aedoeagus gross mit langem schmalen Coecum. Cornuti nicht sehr zahlreich, nach aussen an Länge und Stärke zunehmend.

Holotypus (Männchen), Iraq, Hassi-Omran (eine andere Schreibweise für Haj Omran), Kurdistan, 1760 m. (5780 ft.), 25.VI.1954.

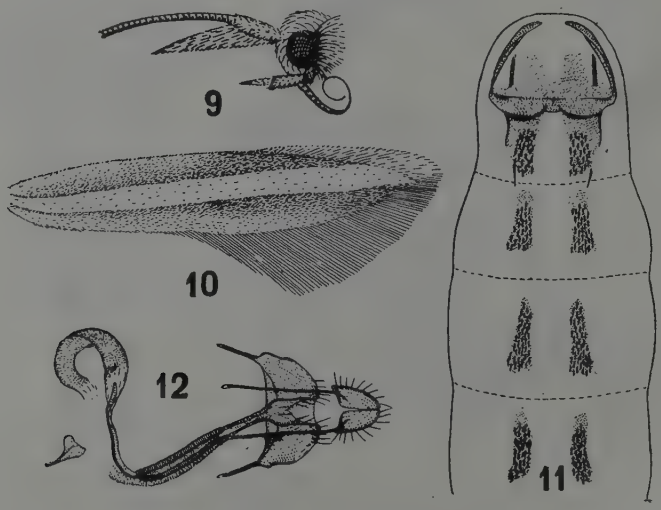
Das Weibchen ist unbekannt.

C. tristraminata, n. sp.

Diese Art steht vielleicht der *C. conspicuella* Zell. genitaliter am nächsten.

Kopf (Fig. 9) und Thorax weiss, gelblich angeflogen. Basalglied der Antennen gelblich mit langem, gelblichem Haarschuppenpinsel. Flagellum ungeringelt. Mittelglied 5/6 des Augendurchmessers, Endglied so lang, wie das Mittelglied (das Exemplar ist sehr schlecht erhalten).

Vorderflügel (Fig. 10) gelb mit breiter weisser, seidenglänzender Längsstrieme. Das Costal- und Dorsalfeld striemenartig weisslich aufgehellt. Fransen an der Costa gelb, am Apex weisslich, am Saum hellgrau. Spannweite 16 mm.



Coleophora tristraminata, n. sp.:
Fig. 9: Kopf.—Fig. 10: Vorderflügel. — Fig. 11: Erste Sternite.—Fig. 12: Weiblicher Genitalapparat.

Querleiste des Verstärkungssystems auf dem I. Sternit (Fig. 11) breit mit schmaler, zweimal unterbrochener Falte am proximalen Rande. Distalrand mit zwei nach aussen gebogenen Falten. Seitenleisten auf dem II. Sternit vorhanden, mässig lang. Sternitenscheiben des III. Paares etwas mehr als doppelt so lang, wie breit, die des IV. Paares 3 mal und die des V. Paares 3 1/2 mal länger als breit.

Weiblicher Genitalapparat (Fig. 12). Lamina abdominalis ziemlich breit. Gonapophyses posteriores mässig lang. Subgenitalplatte am caudalen Ende ab-

gerundet. Introitus Vaginae kelchförmig. Der erste Abschnitt des Ductus Bursae 1 1/2 mal länger als der Introitus Vaginae. Mittelgräte bis zum dritten Abschnitt des Ductus Bursae reichend. Dieser letztere ist mit kleinen schuppenförmigen Dornen besetzt. Signum mässig gross.

Holotypus (Weibchen), Iran, Bam-i-Firuz, Nord-Fars, 10.000 ft., 8.-9.VII. 1950.

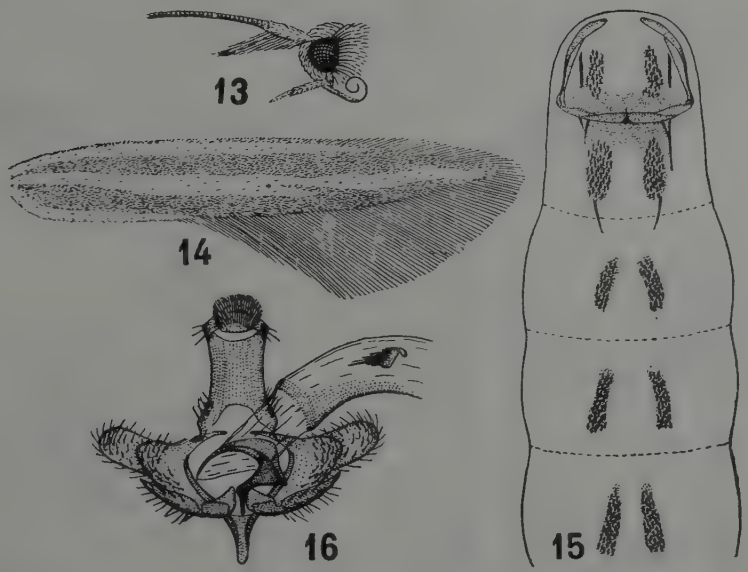
Das Männchen ist unbekannt.

C. similis Stgr.

1 Männchen und 2 Weibchen, Iraq, Haj Omran, Rayat, 5000-6000 ft. 2.-13. VI. 1956 aus Raupen, die E.P. WILTSHIRE an *Centaurea* fand, erzogen.

C. pirizanella, n. sp.

Diese neue Art würde vielleicht der *C. vibicigerella* Zell. genitaliter am nächsten stehen.



Coleophora pirizanella, ns sp.:
FIG. 13: Kopf.—FIG. 14: VorderflügeL—FIG. 15: Ertse I. Sternite.—FIG. 16: Männlicher Genitalapparat.

Kopf (Fig. 13) und Thorax gelblichweiss, Antennen weiss, Haarschuppenpinsel des Basalglieds gelblichweiss. Palpen gelblichweiss, Mittelglied so lang wie der Augendurchmesser, Englied um 1/3 kürzer als das Mittelglied.

Vorderflügel (Fig. 14) gelb, Striemen stark silberglänzend. Costalstrieme erreicht den Apex nicht, sie verläuft etwas von der Costa entfernt. Medianstrieme ist mit der Analstrieme schmal verbunden, sie läuft in den Apex. Dorsalstrieme bis zum Fransenansatz reichend. Fransen hellgrau. Spannweite 18 mm.

Querleiste des Verstärkungssystems auf dem I. Sternit (Fig. 15) ziemlich breit, mit einer Leiste in der Mitte des Distalrandes. Seitenleisten auf dem II. Sternit lang, fast gerade. Sternitenscheiben des III.-V. Paares 3 1/2 mal länger als breit.

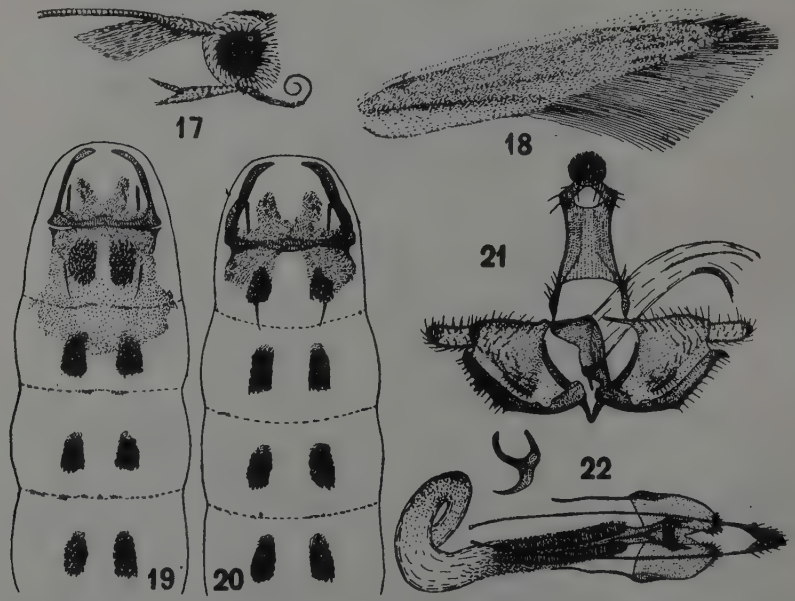
Männlicher Genitalapparat (Fig. 16) dem von *C. vibicigerella* Zell. ähnlich. Gnathos relativ gross. Valve kurze, Valvula gut abgesetzt. Sacculus schmal mit spitz vorgezogener Caudalecke. Vinculum schmal, vorgezogen. Aedoeagus kurz mit schmaler, gebogener Dorsalleiste. Cornuti wenig zahlreich, in einem Bündel stehend.

Holotypus (Männchen), Iran, Pir-i-Zan, 27.IX.1940, [Prov. Fars].

C. canariipennella, n. sp.

Diese schöne Art kann ihren Platz bei *C. agrianella* Rbl. erhalten.

Kopf (Fig. 17) und Thorax weiss, in der Mitte breit kanariengelb, Tegulae weiss, längs des Innenrandes breit kanariengelb. Antennen weiss, Haarschuppen



Coleophora canariipennella, n. sp.:

Fig. 17: Kopf. — Fig. 18: Vorderflügel. — Fig. 19: I. Sternite (Männchen). — Fig. 20: Erste Sternite (Weibchen). — Fig. 21: Männlicher Genitalapparat. — Fig. 22: Weiblicher Genitalapparat.

pinsel im Basalglied kanariengelb. Palpen weiss, oben etwas gelblich angeflogen. Mittelglied um 1/5 länger als der Augendurchmesser. Endbusch wenig kürzer als das Endglied. Dieses letztere ist 2/3 so lang, wie das Mittelglied.

Vorderflügel (Fig. 18) rein kanariengelb, an der Basis des Dorsalfeldes weiss. Costa schmal weiss, Saumfransen hellgrau, um den Apex etwas dunkler mit gelblichem Ton, an der Costa weiss, Spannweite 19-20 mm.

Querleiste des Verstärkungssystems auf dem I. Sternit (Fig. 19, Männchen, Fig. 20, Weibchen) mit zweimal unterbrochener Falte am proximalen Rande. Die Falte am Distalrand schmal, leicht geschwungen. Seitenleisten auf dem II. Sternit angedeutet. Sternitenscheiben des I. Paares mit wenigen Dornen besetzt. Sternitenscheiben des III. Paares 1 1/2 mal, die des IV. und V. Paares zweimal länger als breit.

Männlicher Genitalapparat (Fig. 21). Valve relativ kurz, Valvula nur am Ventralrand deutlich abgesetzt. Sacculus mit gezähntem Caudalrand und deutlicher ventrocaudaler Ecke. An der dorsocaudalen Ecke befindet sich ein kleiner Zahn. Aedoeagus etwas geknickt. Cornuti klein, sehr zahlreich.

Weiblicher Genitalapparat (Fig. 22). Gonapophyses posteriores sehr lang. Subgenitalplatte am caudalen Rande abgerundet. Introitus Vaginae kelchförmig. Der erste Abschnitt des Ductus Bursae 3 mal länger als der Introitus Vaginae. Der zweite Abschnitt ist glashell. Im dritten Abschnitt befinden sich zahlreiche sehr kleine Dornen. Hülle mit starken und langen, schwärzlichen Dornen besetzt. Signum gross mit langen Fortsätzen.

Holotypus (Männchen) und Allotypus (Weibchen) sowie 3 Paratypen wurden von Iraq, Haj Omran, Rayat, 5000-6000 ft. zwischen dem 2. und 13.VI.1956 erbeutet.

C. xanthoargentea, n. sp.

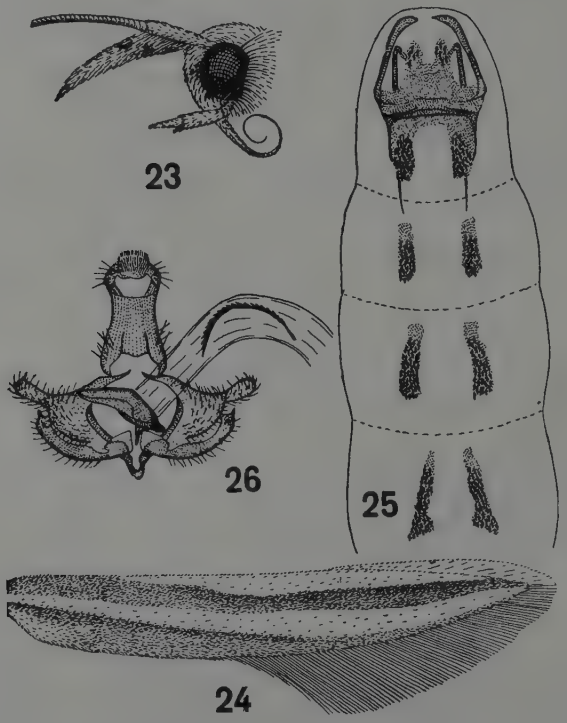
Diese Art scheint genitaliter der *C. involucrella* Chrét. nahe zu stehen.

Kopf (Fig. 23) und Thorax, weiss, Tegulae gelblich angeflogen. Wurzelglied der Antennen weiss, Haarschuppenpinsel oben weiss, unten ockergelb. Flagellum weiss, Palpen weiss, Mittelglied 2/3 des Augendurchmessers, Endbusch kurz, Englied 3/4 so lang, wie das Mittelglied (das Exemplar ist schlecht erhalten).

Vorderflügel (Fig. 24) hell ockerbraun, Keilstrieme wenig abgehoben. Costalstrieme beginnt schmal bei 2/9 der Costalänge, erweitert sich aber plötzlich und wird fast so breit, wie die Keilstrieme. Sie verliert sich in den Fransen. Die Medianstrieme ist mit der Analstrieme verflossen. Sie mündet in den Apex. Dorsalstrieme kurz, undeutlich, Fransen an der Costa weiss. Saumfransen, wie die Flügelfläche gefärbt. Hinterflügel hellgrau, Fransen ockergelbbraun. Spannweite 23 mm.

Querleiste des Verstärkungssystems auf dem I. Sternit (Fig. 25) breit, am proximalen Rande mit schmaler Falte in der Mitte. Am Distalrand ist die Falte breit und in der Mitte unterbrochen. Die Seitenleisten auf dem II. Sternit sind

mittels einer Querleiste verbunden. Sternitenscheiben des I. Paares spärlich mit Dornen besetzt. Die Sternitenscheiben des III.-V. Paares 3 1/2 mal länger als breit.



Coleophora oxanthoargentea, n. sp.:

Fig. 23: Kopf. — Fig. 24: Vorderflügel. — Fig. 25: Erste Sternite. — Fig. 26: Männlicher Genitalapparat.

Männlicher Genitalapparat (Fig. 26). Valve kurz, am Cucullus etwas erweitert, Valvula gut abgesetzt. Sacculus mit zahnförmig vorgezogener Caudalecke und einem kleinen lappenförmigen Höcker darunter, Vinculum zugespitzt. Aedoeagus mässig lang, Coecum kurz. Cornuti zahlreich, in einer gebogenen Reihe stehend.

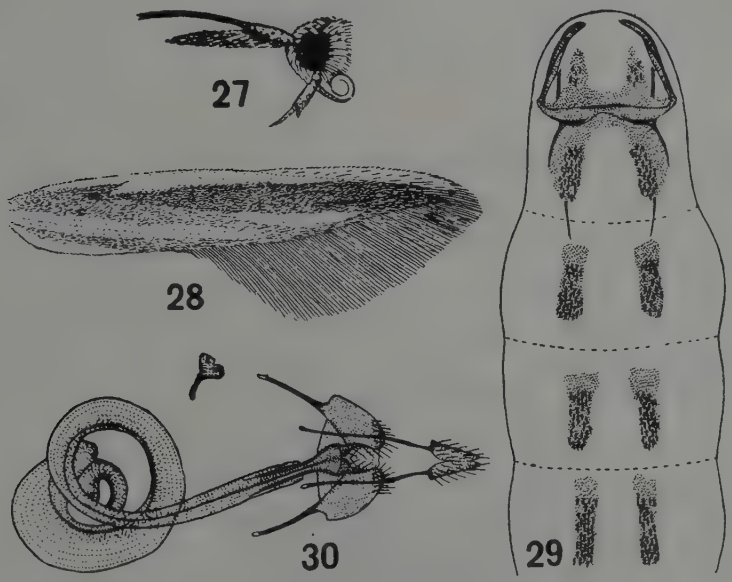
Holotypus (Männchen) und ein Paratypus, Iran, Quli-Kush, 7.VIII.1940, [Prov. Fars].

C. qulikushella, n. sp.

Diese neue Art wird vielleicht der *C. paraononidella* Ams. am nächsten stehen,

Kopf (Fig. 27) und Thorax weiss, Tegulae gelblich angeflogen, Antennen weiss, Haarschuppenpinsel am Basalglied gelblich. Palpen weiss, etwas abstehend beschuppt, Mittelglied etwas kürzer als der Augendurchmesser, Endbusch kurz, Endglied so lang, wie das Mittelglied.

Vorderflügel (Fig. 28) bräunlichgelb, Keilstrieme breit, braun. Die weissen Striemen seidenglänzend; Costalstrieme bis 2/7 schmal, dann durch eine Stufe doppelt so breit. Die Strieme beginnt in einem kleinen Abstand von der Flügelbasis und verläuft in die Fransen. Medianstrieme kurz, etwas gebogen, Analstrieme breit, fast bis zum Saum fortgesetzt, Dorsalstrieme kurz. Fransen an der Costa weiss, um den Apex bräunlichgelb, unter dem Apex weisslich, am Saum hellgrau. Spannweite 16mm.



Coleophora qulikushella, n. sp.:
FIG. 27: Kopf.—FIG. 28: Vorderflügel.—FIG. 29: Erste Sternite.—FIG. 30: Weiblicher Genitalapparat.

Querleiste des Verstärkungssystems auf dem I. Sternit (Fig. 29) mit schmaler Falte in der Mitte des proximalen Randes. Der Distalrand ist in der Mitte stark eingedrückt mit Falten an den Seiten, Seitenleisten auf dem II. Sternit lang, gebogen. Sternitenscheibendes I. Paares spärlich mit Dornen besetzt. Sternitenscheiben des III. und IV. Paares 3 mal, die des V. Paares 4 mal länger als breit.

Weiblicher Genitalapparat (Fig. 30). Lamina abdominalis schmal und kurz. Subgenitalplatte am caudalen Rande abgerundet. Introitus Vaginae kelchförmig,

Ductus Bursae enthält nur die Mittelgräte. Die Seitengräten sind sehr stark reduziert. Hülle nur am Innenrande mit kleinen Dornen besetzt. Signum mässig gross mit zwei kleinen Höckern am Basalrande. Dieser in der Mitte ausgekerbt.

Holotypus (Weibchen), Iran, Quli-Kush, 8.VI.1940, [Prov. Fars].

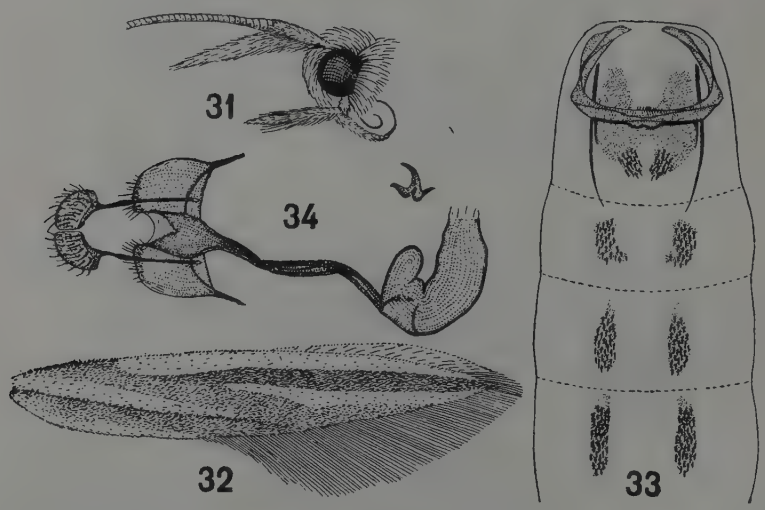
C. giraudi Const.

Iran, Shiraz, 5500 ft., 17.VI.1950, 1 Weibchen, Genital-Präparat No. 22.

C. paragiraudi, n. sp.

Diese neue Art steht der vorhergehenden genitaliter sehr nahe.

Kopf (Fig. 31) und Thorax weiss mit langen Haarschuppen bedeckt. Haarschuppenpinsel am Basalglied der Antennen und das Flagellum weiss. Palpen weiss mit langen Haarschuppen bekleidet, Mittelglied etwas länger als der Augendurchmesser, Endglied kürzer als das Mittelglied.



Coleophora paragiraudi, n. sp.:

Fig. 31: Kopf.—Fig. 32: Vorderflügel.—Fig. 33: Erste Sternite.—Fig. 34: Weiblicher Genitalapparat.

Vorderflügel (Fig. 32) gelb mit olivgrauer Keilstrieme. Die weissen Längsstriemen seidenglänzend. Costalstrieme breit, sie beginnt bei 2/9 der Costalänge und verliert sich in den Fransen. Medianstrieme beginnt in der Flügelmitte und ist bis zum Apex fortgesetzt. Analstrieme breit, sie erreicht den Saum nicht. Dorsalstrie-

me schmal. Fransen an der Costa weiss, um den Apex bräunlich, am Saum hellgrau. Spannweite 21 mm.

Querleiste des Verstärkungssystems auf dem I. Sternit (Fig. 33) mit sklerotisiertem Proximalrand und stark in der Mitte gewellter Falte am Distrand. Seitenleisten auf dem II. Sternit mässig lang. Sternitenscheiben des I. Paares ohne Dornen. Sternitenscheiben des III. Paares 2 mal, die des IV. Paares 3 1/2 mal und die des V. Paares 4 mal länger als breit.

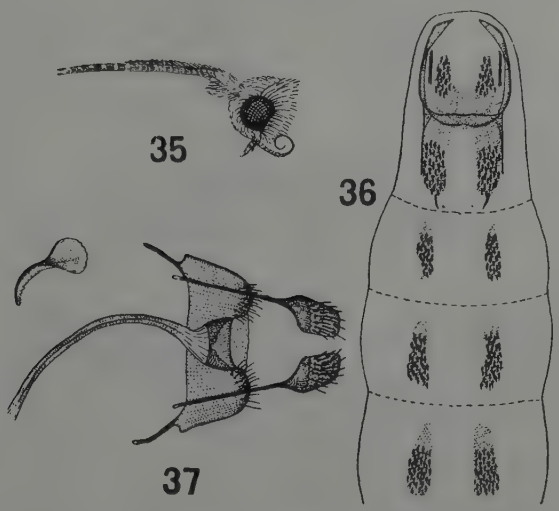
Weiblicher Genitalapparat (Fig. 34). Lamina abdominalis breit, Subgenitalplatte fast doppelt so breit wie lang. Introitus Vaginae kelchförmig. Der erste Abschnitt des Ductus Bursae 1 1/2 mal so lang, wie der Introitus Vaginae. Der zweite Abschnitt stark aufgeblasen und sklerotisiert. Signum mässig gross mit Seitenfortsätzen, die am Rande durch sklerotisierte Schienen verstärkt sind.

Holotypus (Weibchen), Iran, Sineh-Sephid, 27.VII.1940, [Prov. Fars].

C. candidella, n. sp.

Diese Art gehört gleichfalls zu derselben Gruppe, wie die vorhergehende.

Kopf (Fig. 35) und Thorax weiss mit kaum erkennbarem gelblichen Anflug. Basalglied der Antennen mit kurzem weissen Haarschuppenbusch. Das erste 1/3 des Flagellum oben hellgelb beschuppt. Der übrige Teil des Flagellums ist gelblich geringelt. Palpen sehr kurz. Mittelglied 2/5 des Augendurchmessers, Endbusch kurz, Endglied so lang wie das Mittelglied.



Coleophora candidella, n. sp.:
FIG. 35: Kopf. — FIG. 36: Erste Sternite. — FIG. 37: Weiblicher Genitalapparat.

Vorderflügel weiss, nur an den Rändern ganz schwach gelblich angeflogen, sonst zeichnungslos. Fransen weiss. Hinterflügel gelblichweiss mit weissen Fransen. Spannweite 12 mm.

Querleiste des Verstärkungssystems auf dem I. Sternit (Fig. 36) breit, in der Mitte etwas eingeschnürt. Die Falten auf beiden Rändern schmal. Seitenleisten auf dem II. Sternit lang. Sternitenscheiben des III. Paares 3 mal, die des IV. Paares 2 1/2 mal und die des V. Paares 3 mal länger als breit.

Weiblicher Genitalapparat (Fig. 37). Lamina abdominalis breit. Subgenitalplatte bedeutend breiter als bei der vorher beschriebenen Art. Introitus Vaginae kelchförmig, breit, am distalen Rande ziemlich stark sklerotisiert, an der Basis glashell. Signum relativ grösser als bei *C. transcaspica* Toll.

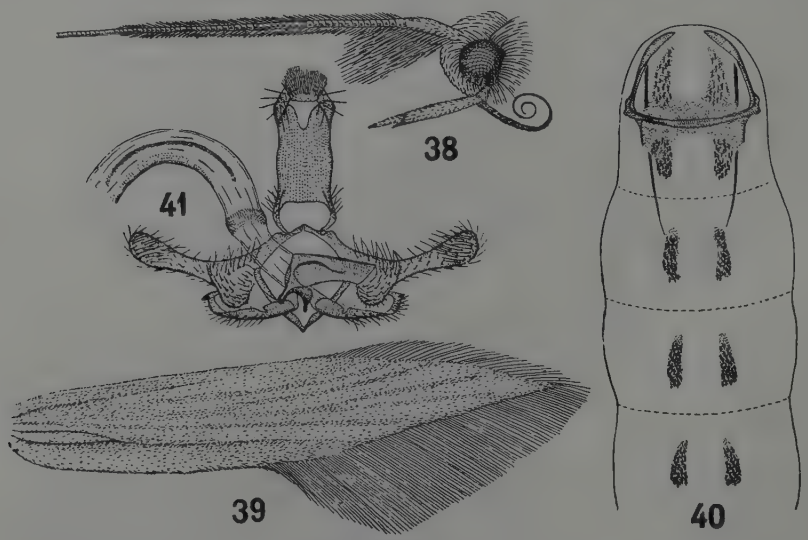
Holotypus (Weibchen) und Paratypus, Bagdad, 4. IX. 1952.

Das Männchen ist unbekannt.

C. magnatella, n. sp.

Diese neue Art gehört zur *botaurella*-Gruppe. Oberflächlich ist sie schwer von *C. botaurella* H.-S. zu unterscheiden.

Kopf (Fig. 38) und Thorax beingelb. Antennenbasalglied mit breitem, abgestütztem Haarschuppenpinsel. Flagellum beingelb, bis 3/5 seiner Länge oben mit abstehenden Schuppen besetzt. Palpen beingelb, Mittelglied 1 4/5 so lang, wie



Coleophora magnatella, n. sp.:

Fig. 38: Kopf.—Fig. 39: Vorderflügel.—Fig. 40: Erste Sternite.—Fig. 41: Männlicher Genitalapparat.

der Augendurchmesser, Endbusch kaum die halbe Endgliedlänge erreichend, Endglied von halber Mittelgliedslänge.

Vorderflügel (Fig. 39) gelblichweiss, Adern kaum merklich dunkler angelegt. Fransen gelblichweiss. Spannweite 18-23 mm.

Querleiste des Verstärkungssystems auf dem I. Sternit (Fig. 40) ziemlich schmal. Falten an ihren Rändern in der Mitte verschmälert. Seitenleisten auf dem II. Sternit kurz. Sternitenscheiben des I. Paares spärlich bedornt. Sternitenscheiben des III. und IV. Paares 3 1/2 mal, des des V. Paares 3 mal länger als breit.

Männlicher Genitalapparat (Fig. 41). Tegumendach hoch, Gnathos gross, Valve lang, am Cucullus erweitert, Valvula gut abgesetzt. Sacculus am caudalen Rande abgerundet mit einem kleinen Zahn an der dorsocaudalen Ecke. Aedoeagus breit mit kurzem Coecum. Cornuti sehr zahlreich, in langer Reihe stehend.

Holotypus (Männchen), Margelan, Usbekistan, CHRISTOPH leg., und 3 (Paratypen) aus Iran, Alvand, 7000 ft., 21.VI.1938, [Prov. Hamadan].

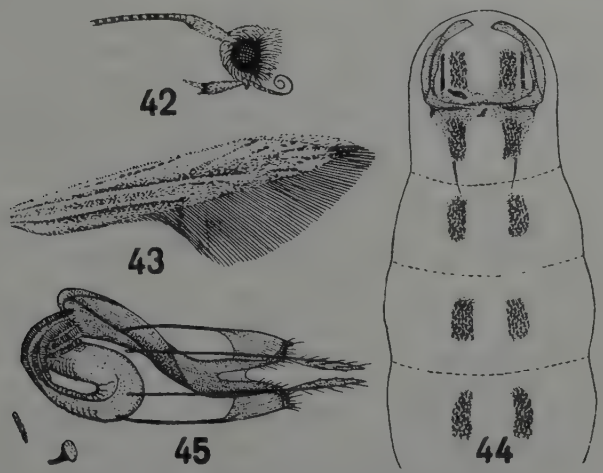
C. laripennella Ztt.

Iran, Shiraz, 25.IV.1941, ein Männchen, Genitalpräparat No. 36.

C. botauripennella, n. sp.

Diese Art gehört in die *linearielle*-Gruppe und ist mit *C. laripennella* Ztt. sehr nahe verwandt.

Kopf (Fig. 42), Thorax, Antennenbasalglied und die ersten 4 Flagellumglieder hellgrau. Weiterhin ist das Flagellum weiss, graubraun geringelt. Palpen



Coleophora botauripennella, n. sp.:
FIG. 42: Kopf.—FIG. 43: Vorderflügel.—FIG. 44: Erste Sternite.—FIG. 45: Weiblicher Genitalapparat.

innen hellgrau, aussen grau. Mittelglied wenig länger als der Augendurchmesser, Endbusch kurz, Endglied 2/3 der Mittelgliedslänge.

Vorderflügel (Fig. 43) gelbgrau, Costalfeld breit weiss, am Innenrande allmählich in die Grundfärbung übergehend. Linien weiss, etwas undeutlich, sparsam durch schwärzliche Schuppen markiert. Fransen an der Costa weiss, um den Apex gelbgrau, am Saum grau. Spannweite 14 mm.

Längsleisten des Verstärkungssystems auf dem I. Sternit (Fig. 44) mit Seitenlappen. Querleiste mit Falte in der Mitte des proximalen Randes. Die Falte am Distalrand in der Mitte weit unterbrochen. Seitenleisten auf dem II. Sternit kurz, undeutlich. Sternitenscheiben des III. und IV. Paares 2 1/2 mal, die des V. Paares 3 mal länger als breit.

Weiblicher Genitalapparat (Fig. 45) dem von *C. laripennella* Ztt. sehr ähnlich. Lamina abdominalis lang und schmal, hinten zugespitzt. Gonapophyses anteriores und posteriores länger als bei *C. laripennella* Ztt. Subgenitalplatte am caudalen Rande tiefer eingeschnitten Der drei Gräten enthaltende erste Abschnitt des Ductus Bursae etwas kürzer. Signum mit kurzem Hauptfortsatz. Bedorntes Körperchen schmaler und länger.

Holotypus (Weibchen), Iran, Teheran 27. VIII. 1939.

Das Männchen ist unbekannt.

C. dianthi H-S.

Iraq, Haj Omran, Rayat, 5000-6000 ft., 2.-13.VI.1956.

C. griseicornella, n. sp.

Diese neue Art gehört in die *salicorniae*-Gruppe und ist mit *C. salicorniae* Hein. und Wck. nahe verwandt.

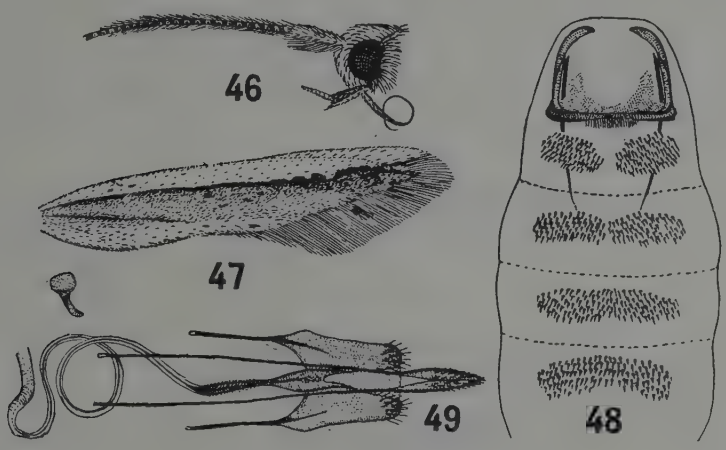
Kopf (Fig. 46) und Thorax schneeweiss, Antennen weiss und schwärzlichbraun geringelt. Basalglied und die basale Hälfte des Flagellums oben mit langen Haarschuppen bedeckt. Diese Haarschuppen sind grau mit weissen Spitzen. Mittelglied der Palpen oben hellgrau, so lang wie der Augendurchmesser, Endbusch kurz-Endglied etwas kürzer als das Mittelglied.

Vorderflügel (Fig. 47) schneeweiss mit breiter grauer Mittelstrieme, deren Hinterrand wenig scharf begrenzt ist. Die schneeweisse Costalstrieme ist von der grauen Mittelstrieme durch eine etwas zerrissene schwarze Linie getrennt. Einige schwärzliche Schuppen sind auf der Flügelfläche zerstreut.

Fransen an der Costa schneeweiss, Saumfransen grau. Spannweite 14 mm.

Querleiste des Verstärkungssystems auf dem I. Sternit (Fig. 48) in der Mitte etwas verschmälert. Die Falten an ihrem proximalen und distalen Rande in der Mitte schmal. In der Mitte des Distalrandes befindet sich eine sklerotisierte, quergerillte Leiste. Sternitenscheiben des I. Paares ohne Dornen, die des II. Paares breiter als lang und die des III.-V. Paares sind miteinander paarweise verflossen und ziemlich dicht mit dünnen Dornen besetzt.

Weiblicher Genitalapparat (Fig. 49). Subgenitalplatte etwas länger als breit, am caudalen Rande tief eingeschnitten. Gonapophyses posteriores 3 1/2 mal länger als die Gonapophyses anteriores. Lamina abdominalis mit kurzen Borsten spärlich



Coleophora griseicornella, n.s sp.:

FIG. 46: Kopf. — FIG. 47: Vorderflügel. — FIG. 48: Erste Sternite. — FIG. 49: Weiblicher Genitalapparat.

besetzt. Introitus Vaginae kelchförmig, schmal. Der erste Abschnitt des Ductus Bursae kürzer als der Introitus Vaginae. Die Mittelgräte beginnt im Introitus Vaginae und ist bis zum dritten Abschnitt des Ductus Bursae verlängert. Im dritten Abschnitt befinden sich zahlreiche sehr kleine Dornen.

Holotypus (Weibchen), S.W. Iran, Shiraz, 7000 ft., 26.VII.1950.

Das Männchen ist unbekannt.

C. salicorniae Hein. und Wck.

Iran, Shiraz, 31.VIII.1940, zwei Weibchen, Genital-Präparat No. 43.

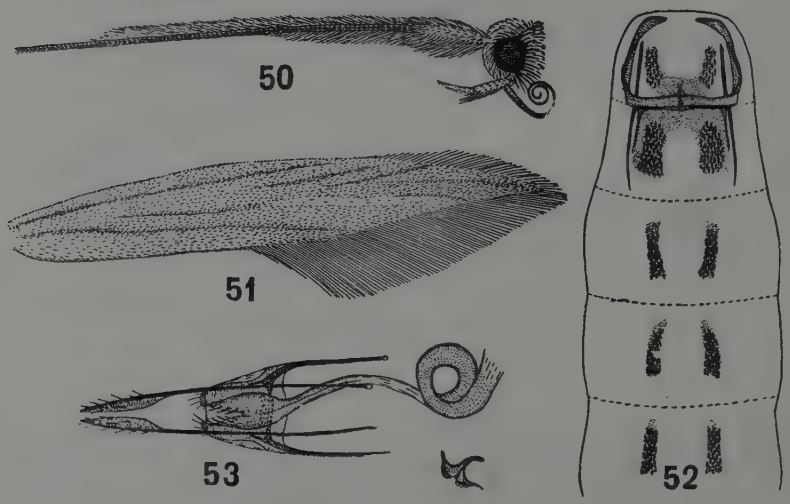
C. sivandella, n. sp.

Diese neue Art gehört zur *wockeella*-Gruppe und steht der *C. wockeella* Zell. genitaliter nahe.

Kopf (Fig. 50) und Thorax beingelb, Antennen bis 2/3 ihrer Länge durch abstehende beingelbe Haarschuppen verdickt. Das nackte 1/3 des Fagellums ist ungeringelt. Palpen beingelb. Mittel- und Endglied so lang wie der Augendurchmesser. Endbusch des Mittelgliedes etwas abgeflacht, bis zur halben Endgliedslänge reichend.

Vorderflügel (Fig. 51) beingelb mit sehr undeutlich gelb markierten Adern. Unter der Ader m_2 befindet sich ein wenig auffallender weisser Längsstreif. Fransen an der Costa weisslich, um den Apex hell bräunlich, am Saum gelbgrau mit schwachem rosa Schimmer. Spannweite 22 mm.

Querleiste des Verstärkungssystems auf dem I. Sternite (Fig. 52) ziemlich breit mit einer sklerotisierten Verstärkung in der Mitte. Die Falte am proximalen Rande fehlend. Distalrand fast gerade mit durchlaufender Falte. Sternitenscheiben des III.-V. Paares 3 mal länger als breit.



Coleophora sivandella, n. sp.:
FIG. 50: Kopf. — FIG. 51: Vorderflügel. — FIG. 52: Erste Sternite. — FIG. 53: Weiblicher Genitalapparat.

Weiblicher Genitalapparat (Fig. 53). Lamina abdominalis schmal, zugespitzt. Gonapophyses posteriores doppelt so lang, wie die Gonapophyses anteriores. Subgenitalplatte caudal etwas verschmälert. Introitus Vaginae kelchförmig, am Caudalrand tief eingeschnitten. Ductus Bursae enthält nur eine kurze Mittelgräte. Der zweite Abschnitt ist glashell; der dritte Abschnitt ist gewunden und schwach sklerotisiert. Signum gross mit schmalen Seitenfortsätzen, in der Mitte des Basalrandes mit einer Auskerbung.

Holotypus (Weibchen), Iran, Sivand, 16.V.1941.

THE STRUCTURE OF THE HEAD CAPSULE AND MOUTH PARTS OF THE CATERPILLAR OF *COSSUS L-NIGRUM* B.-B.

[*Lepidoptera : Cossidae*]

(with 9 Text-Figures)

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CONTENTS

I. Introduction. — II. The head capsule. — III. The mouth parts. — IV. Summary. — V. References.

I. INTRODUCTION

The examination of some of the works concerned with the morphology of caterpillars has revealed that the homologies of the different structures of a caterpillar is not clearly understood in the field of entomology in general and among our research students in particular. This fact has stimulated the author to carry out the task of presenting a very clear picture of the comparative anatomy of caterpillars. The author's previous training in the field of the morphology of trichopterous larvae was of great help. The phylogenetic relationship between the larvae belonging to the two orders is both evident and interesting.

In choosing the material for the first paper on the comparative anatomy of caterpillars, many specifications of this material were put in mind as necessary. The caterpillar ought to be of a comparatively large size and of a very common occurrence, in order to be easy enough for the studies by the undergraduate students. The chaetotaxy of the head ought to be of the primary type, so as to show clearly the plan of the distribution of the primary bristles in the adult larval stage. Finally, the different structures of the caterpillar should be simple and without plenty of

morphological modifications and adaptations. The examination of several caterpillars has shown that the caterpillar *Cossus l-nigrum* B.-B. could satisfy these requirements.

II. THE HEAD CAPSULE

According to SNODGRASS (1928), the insect head is a telocephalon, composed of the prostomial part of an annelid or the archicephalon, and six poststomial segments. These latter segments are the preantennal, the antennal, the postantennal, the mandibular, the first maxillary and the second maxillary segments. The latter mentioned three segments are called the gnathal segments. The labrum is a derivative of the prostomial part of the insect head and the appendages of the gnathal segments constitute the insect's mouth parts. However, the segmental nature of an adult insect head can not be noticed owing to the complete fusion of the component segments. The sutures dividing the head capsule into areas are of a functional importance rather than of a phylogenetic significance.

The sutures dividing the head capsule of the caterpillar studied are of two types. The first type of sutures is in the form of a line of weak sclerotization in the cuticle, while the second type of sutures is in the form of a linear invagination in the cuticle which forms an internal double-walled ridge. The latter ridge serves for muscle attachments and adds to the endoskeletal support of the head capsule. This type of sutures appears externally in the form of an elongated groove.

On the anterior surface of the head capsule (Fig. 1), there is a V-shaped suture which has its apex directed dorsally. This suture is in the form of a linear weak sclerotization in the cuticle. Inner to this latter mentioned suture, there is another V-shaped suture which is in the form of a linear invagination in the cuticle and which forms an internal ridge. From this ridge, and at a point a little below its middle, originates the anterior arms of the tentorium. This suture is obviously the epistomal suture. SNODGRASS (1935) mentioned that a facial suture that contains the anterior tentorial pits, is tobe identified as the epistomal suture. The epistomal suture is the line which separates the ventral clypeus from the dorsal frons. Consequently, the triangular sclerite which is enclosed within the arms of the epistomal suture is the clypeus while the V-shaped sclerite which is found on both sides of the arms of the epistomal suture is the frons. The V-shaped suture which is found on both sides of the frons is the frontal suture. In the case of the caterpillar studied a facial medio-dorsal coronal suture is absent, since the apex of the V-shaped frons reaches the dorsal border of the head capsule (Fig. 1). In many other caterpillars (PETERSON, 1951), the coronal suture is present. The labral muscles are attached internally on the apex of the frons, a fact which further proves its identity. The membranous sheet which connects the labrum with the ventral border of the clypeus is termed the anteclypeus. KRAFKA (1923) used the term preclypeus instead of anteclypeus. CRAMPTON (1921) stated that when the suture between the clypeus and

frons is absent, a line running between the bases of the two mandibles will posteriorly limit the clypeus. CRAMPTON's opinion has mislead him and he considered the clypeus of caterpillars to be the membranous sheet which connects the labrum with the clypeus (the anteclypeus of this work), while he called the true clypeus the frons. In fact, CRAMPTON, but not SNODGRASS, has missed the truth that in some insects, the epistomal suture is arched dorsally so as to increase the clypeal region at the expance of the frontal region and thus the bases of the mandibles do not coincide any more with the posterior limit of the clypeus.

In the case of caterpillars, a lateral sclerite is found on each side of the frontal suture, which sclerite forms a great part of the head capsule. This lateral sclerite is divided, in some insects, by sutures into component areas. However, since this lateral sclerite is, in the case of caterpillars, not divided by sutures into component areas, it is termed in this work the parietal. Each parietal carries six ocelli on its ventro-lateral side which form the larval eye. On the ventral edge of each parietal, there are anteriorly a peg and posteriorly a socket which correspond to and articulate with an anterior socket and a posterior peg on the dorsal edge of the mandible. The larval antenna is three-segmented and is found ventrally on a membranous area located lateral to the mandible.

On the posterior side of the head capsule, there is a third suture which is in the form of linear groove forming an internal ridge and which runs from the dorsal border of the head capsule to the posterior articulation of the mandible (Figs. 2 and 7). The posterior tentorial pit is found near the upper end of this suture. This suture is evidently the hypostomal suture of SNODGRASS (1935) and the sclerite found median to this suture is the hypostomal sclerite. The two hypostomal sclerites do not meet each other in the mid-line to form a complete hypostomal bridge between the base of the maxillo-labial complex and the foramen magnum (Fig. 7).

The distribution of bristles and pits on the head capsule

The bristles are cuticular derivatives with membranous connections or alveoli at their bases. The pits are saucer-shaped perforations on the skin which resemble the scars of broken bristles. The author has observed that in many works concerned with the chaetotaxy of caterpillars, pits are wrongly identified as broken bristles and, sometimes, when a bristle is very minute it is wrongly identified as a pit. It ought to be said that the author doubts the accuracy of the greatest majority of the works concerned with the chaetotaxy of the head capsules of caterpillars. In this work, every possible care has been given to produce a very accurate plan for the distribution of bristles and pits on the head capsule and mouth parts. About fifty specimens were examined. Several specimens were boiled in caustic potash and mounted in glycerol. During the examination of the material mounted in glycerol, it is usually rolled round its longitudinal axis in order to see the pit or bristle from different angles to differentiate accurately between a very minute bristle and a

pit. The clypeal, the frontal and the parietal sclerites only carry bristles and pits, while the hypostomal sclerite carries neither.

The clypeus carries three bristles on each side. Two of these bristles are found laterally and are arranged in a horizontal line parallel to the ventral edge of the clypeus while the third bristle is found inner to and near the middle of the epistomal suture. A pair of pits is found near the centre of the clypeus on both sides of the median longitudinal line (Fig. 1).

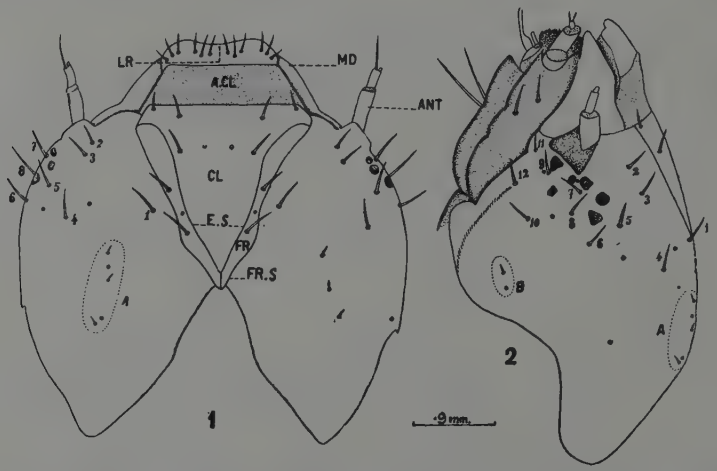

FIG. 1: Facial view of the head capsule (A. CL, anteclypeus; ANT, antenna; CL, clypeus; E.S, epistomal suture; FR, frons; FR.S, frontal suture; LR, labrum; MD, mandible). — FIG. 2: Lateral view of the head capsule.

Each limb of the V-shaped frons carries a pair of bristles, one is located behind the other. A pit is found between these two bristles (Fig. 1).

Each parietal carries 16 bristles and 9 pits (Fig. 2). Of these bristles and pits, there is on the facial side a group which consists of three very minute bristles associated with two pits. This group is numbered A in this work (Fig. 1). On the posterior side, there is another group which consists of a single bristle associated with a single pit. This group is numbered B in this work (Fig. 2). The remaining twelve bristles are given numbers from 1 to 12 in such a way that the bristle of a smaller number is either nearer to the mid anterior line or more ventral than the bristle with a next greater number. In the case of the caterpillars studied, the bristle numbered 1 is nearer to the anterior mid-line than the bristle numbered 2 while this latter bristle is ventral to the bristle numbered 3. The remaining six pits on the parietal are arranged in the following way: one pit between the bristles numbered 1 and 4, one pit between the bristles numbered 4 and 6, one pit is located laterally between

the groups numbered A and B, one pit between the two ocelli found in front of the bristle numbered 7, one pit between the bristles numbered 8 and 10 and finally a pit very near to the base of the bristle numbered 9.

The author's experience in the morphology of trichopterous larvae makes him believe that the location of the pits is greatly useful in the identification of bristles so as to give a constant number to one and the same bristle in the different species of caterpillars. The author also believes that an accurate study of the setal arrangement on the head capsules of the different species of caterpillers, particularly on the parietal sclerite, could result in the formation of a key for the Egyptian caterpillars. This target will be the subject of further papers by the author.

III. THE MOUTH PARTS

The mouth parts of caterpillars are prominant and are of the biting type. They consist of a labrum, a pair of mandibles and a pair of maxillae which are proximally fused with the median labium. The head of a caterpillar is hypognathous.

The labrum

The labrum is an elipsoid structure which, according to SNODGRASS (1928), is median preoral lobe of the prostomium. The labrum is covered by a sclerotised plate (Fig. 3) which, in the case of the caterpillar studied, fails to reach the margins of the labrum at any side. There is a notch in the middle of the ventral margin of

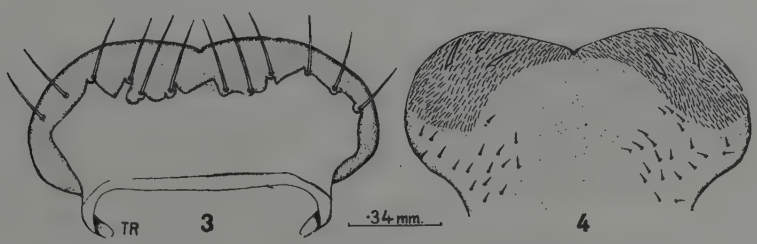

FIG. 3: Anterior view of the labrum (TR, torma). — FIG. 4: Posterior view of the labrum.

the labrum. A pair of processes, the tormae, are given by the dorso-lateral corners of the labrum, which processes serve for muscle attachments. The tormae are twisted into the posterior surface of the labrum. The labrum carries six bristles and a pit on each side of the anterior surface. The posterior side of the labrum (Fig. 4) is membranous and is covered by numerous fine spines. There are also, on each side of this posterior surface, three conical spines which are near the ventral margin.

The posterior membranous wall of the labrum forms a part of the epipharynx or the anterior wall of the preoral cavity. A distinct lobe-like epipharynx is not found in caterpillars.

The mandibles

The mandibles are conical structures and are of the biting type. The two mandibles of both sides are symmetrical structures. The medio-ventral edge of the mandible carries four teeth (Fig. 5). There are two bristles and a single pit on the

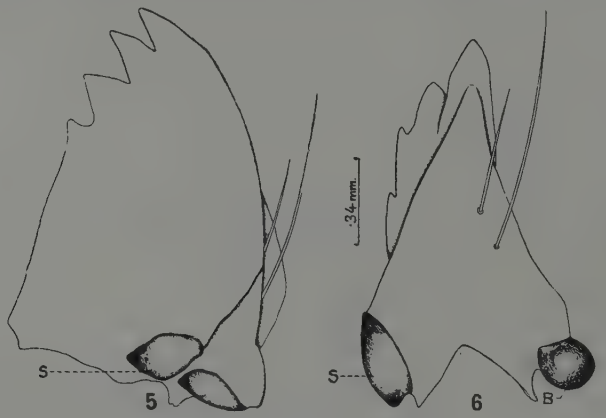

FIG. 5: Anterior view of the right mandible (S, socket). — FIG. 6: Lateral view of the mandible (B, ball; S, socket).

lateral side of the mandible. On the dorsal edge of the mandible, there are an anterior socket and a posterior peg for the articulation with the corresponding anterior peg and posterior socket on the ventral edge of the parietal (Fig. 6).

The maxillo-labium

In the case of caterpillars, the lateral maxillae and the median labium are proximally connected together and they will be treated here as a single unit.

The maxilla is composed of a cardo, a stipes, a palpifer segment, a median galea and a lateral maxillary palp (Fig. 7). SNODGRASS (1928) has homologised the insect first maxilla with an ordinary thoracic leg. According to his opinion, both structures are derived from a uniramous appendage. If such is the case, he came to the conclusion that the limb base has been divided into a subcoxal region to give the subcoxa of a thoracic leg or the cardo of a maxilla, and a coxal region to give the coxa of a thoracic leg or the stipes of a maxilla. The palpifer is not a true segment but it is a secondary subdivision of the coxal region or the stipes, since muscles run

through the palpifer segment without having any attachments or insertions upon it. The galea and lacinia are coxal endites, while the maxillary palp is a derivative of the telopodite of the uniramous appendage.

In the case of caterpillars, there is usually a single coxal endite lobe. In the case of the related trichopterous larvae, the similar single endite lobe found is definitely the outer one or the galea (NIELSEN 1942; KHALIL, 1953). NIELSEN (1942) discovered an inner endite lobe of the maxilla, or the lacinia, in some trichopterous larvae. TILLYARD (1922) could discover two endite lobes in the maxilla of some caterpillars. When a single coxal endite is only present in caterpillars it is definitely the outer one or galea. The galea of both sides give the proboscis of the adult.

In a posterior view of the maxilla (Fig. 7), the galea does not appear to be arising from the palpifer segment. The sclerite covering the first palpal segment also covers the proximal part of the galea. Owing to this deceiving appearance, some morphologists consider the first segment of the maxillary palp as a second

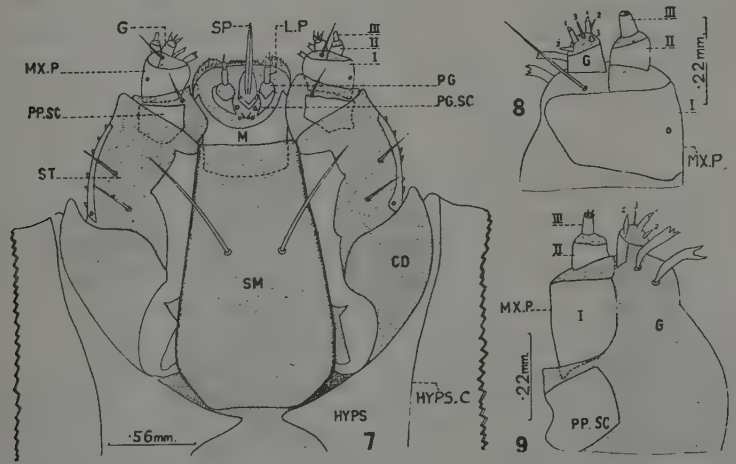

FIG. 7: Posterior view of the maxillo-labium (CD, cardo; G, galea; HYPS, hypostomal sclerite; HYPS.S, hypostomal suture; L.P, labial palp; M, mental sclerite; MX.P, maxillary palp, I, II and III; PG, palpiger segment; PG.SC, palpiger sclerite; PP. SC, palpifer sclerite; SM, submentum; SP, spinneret; ST, stipes). — FIG. 8: Posterior view of the galea and maxillary palp (G, galea, and 1, 2 and 3:three pairs of sensory rods on its apex; MX.P, maxillary palp, I, II and III).— FIG. 9: Anterior view of the palpifer segment, the galea and the maxillary palp (G, galea, and 1, 2 and 3: three pairs of sensory rods on its apex; MX.P, maxillary palp, I II and III; PP.SC, palpifer sclerite).

palpifer segment. However, the examination of the maxilla from the anterior side reveals that both the galea and maxillary palp articulate with the papifer segment (Fig. 9), and the proximal part of the galea is fused laterally with the median side

of the first palpal segment. Thus, the maxillary palp of the caterpillar studied is three-segmented.

The coxal articulates dorsally with the hypostomal lobe and ventrally with the stipes. It carries neither bristles nor pits. The stipes carries a pair of bristles and a single pit. An elongated sclerotised plate covers the median side of both the cardo and stipes. The palpifer segment carries a sclerotised plate and a single bristle. The maxillary palp is three-segmented. The sclerite on the first segment is not in the form of a complete ring and it carries a single pit. Some sensory papillae are found on the soft apex of the third palpal segment. The sclerite covering the terminal part of the galea is not in the form of a complete ring. The galea carries one bristle posteriorly and a pair of bristles anteriorly. On the membranous apex of the galea there are three pairs of sensory rods (Figs. 8 and 9).

The labium is median and consists of the submentum proximally, and the labial lobe distally which carries the mental sclerite. SNODGRASS (1928 and 1935) divided the labium into a distal movable prelabium with all the muscles of the labium inserted on it and a proximal postalium. Following SNODGRASS' views, the dorsal membranous part of the labium is identified as the postlabium since it furnishes no attachments for the labial muscles. Sometimes, the proximal part of the labium is termed the submentum and the distal part the mentum. However, CRAMPTON (1921) used the terms submentum and mentum for the secondary subdivisions of the postlabium, while calling the prelabium the eulabium. This lead him to give the names submentum and mentum to one and the same structure (submentum) in different insects. The term labial lobe, describing the conical, distal and movable part of the labium, is established in trichopteran terminology and will be applied for caterpillars to describe the same structure.

The submentum articulates dorsally with the hypostomal lobes and it carries a pair of bristles. No sclerites cover the surface of the submentum.

The labial lobe is a conical structure, which carries the mental sclerite. Ventral to the mental sclerite there is a pair of very minute bristles. Laterally, the labial lobe carries a pair of two-segmented labial palps. Each of these labial palps is carried on a palpiger segment which is covered by a palpiger sclerite. The median spine-like spinneret arises from between the palpiger segments. The orifice of the silk duct is found at the tip of the spinneret. The anterior side of the labial lobe is covered by numerous fine bristles which represent the hypopharynx (Fig. 9).

IV. SUMMARY

(1) The facial side of the head capsule is made of a triangular clypeus, on both sides of which there is a V-shaped frons. Both the epistomal and frontal sutures are V-shaped. The lateral walls of the head are covered by the two parietal sclerites, each of which carries six ocelli. On the posterior side of the head there are

two lobe-like hypostomal sclerites. The latter two sclerites do not articulate with each other in the middle line to form a complete hypostomal bridge. A membranous sheet, the anteclypeus, connects the clypeus to the labrum. The larval antenna is three-segmented.

(2) The clypeus carries three pairs of bristles and a pair of pits, the frons carries two pairs of bristles and a pair of pits, and the parietal sclerite carries sixteen bristles and nine pits. The hypostomal sclerite carries neither bristles nor pits.

(3) The labrum does not represent the appendages of a head segment, but it is a median preoral lobe. It carries six pairs of bristles and a pair of pits. Each mandible carries four teeth on its median side and a pair of bristles and one pit on its lateral side. The maxilla carries a lateral three-segmented maxillary palp. Three pairs of sensory rods are found on the soft apex of the median galea. The labium consists of a proximal submentum and a distal labial lobe which carries the mental sclerite. The submentum gives origin to no labial muscles. The labial lobe carries a pair of palpiger segments each of which is covered by a palpiger sclerite. The labial palp is two-segmented. The spinneret is spine-like and originates from between the palpiger segments. The opening of the duct of the silk glands is found at the tip of the spinneret.

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INFESTATION OF COTTON WITH SPIDER MITES

[*Acarina*]

PART I: THE SPECIES OF SPIDER MITES FOUND ON COTTON PLANTS IN EGYPT AND THEIR PREDATORS

(with 2 Text-Figures and 2 Tables)

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CONTENTS

I. Introduction. — II. Methods and Technique. — III. Results. — IV. Discussion. — V. Summary. — VI. Acknowledgment. — VII. References.

I. INTRODUCTION

During 1956 and 1957, the authors carried out studies on the population densities of spider mites in cotton fields in certain localities in Egypt, specially after the use of certain insecticides for the control of cotton insect pests. In the course of these studies, one of the first considerations was to determine the different species of mites present and the differences in their relative populations in fields not treated with insecticides. This opportunity was also taken to survey the different species of mites predators found in cotton fields.

The present investigation, therefore, deals with (1) the survey of the different species of spider mites and their predators found on cotton plants in certain localities in Egypt, i.e., Giza, Abou-Hammad, Itiah El Baroud and Sakha, and (2) the study of the natural population densities of these different species of mites in relation to each other, and the periods of their appearance in cotton fields.

II. METHODS AND TECHNIQUE

Specimens of phytophagus and predatory mites found on cotton plants throughout the course of this study were mounted in HOYER's medium according to the method described by PRITCHARD and BAKER (1953).

For studying the population densities the following technique of sampling and counting was followed:

A. Sampling

In the early season, counts of mites were made on samples of whole seedlings. Samples of twenty seedlings were collected at random from the field under test, kept in tightly closed paper bags and taken immediately to the laboratory for counting.

Later on the season, samples of 100 leaves each were used. The leaves of each sample were picked from 50 random plants in any given field, taking two leaves from each plant, one from the lower part of the plant and the second from its top. Each sample was also kept in a tightly closed paper bag until counts were made in the laboratory in the same day.

B. Counting

Counts for all the living individuals of mites and predators on the two surfaces of each leaf of the sample were made with the aid of a binocular microscope. The leaf area was determined by measuring the blueprint of twenty leaves, with a planimeter according to the method used by KREUSLER (1877), and ROUSSEL et al (1951). The mean surface was then calculated. The number of mites per 100 inch square of leaves surfaces was taken as an infestation index on the basis of which all comparisons mentioned in this work were made.

This infestation index was calculated according to the formula $I = \frac{T}{N \times M} \times 100$, where I: infestation index; T: total numbers of mites in the sample; N: number of leaves in the sample; and M: mean area of leaves.

The countings were done at 7-14 days intervals throughout the whole season from the seedling stage to the maturing of the crop.

III. RESULTS

1. Species of mites found on cotton

TETRANYCHIDAE ; *Tetranychus cinnabarinus* (Bois.), *Oligonychus terminalis* Sayed, *Eutetranychus banksi* (McG.) (=*Anychus orientalis* (Zacher)). — TENUIPALPIDAE: *Brevipalpus obovatus* Donnadieu (=*B. inornatus* (Banks)).—TARSONEMIDAE: *Tarsonemus* spec.

The mean monthly population indices of these five species separately on cotton plants in fields in four localities in Egypt are given in Tables I and II. The following is a brief discussion concerning each species.

TABLE I

Monthly population means of the spider mites T. cinnabarinus, O. terminalis, E. banksi, Tarsonemus *spec., and* B. obovatus *separately on cotton plants in fields not treated with insecticides. (Giza and Abou-Hammad,* 1956-1957)

Months	1956					1957				
	T. cinn.	O. term.	E. banksi	Tars. spec.	B. obov.	T. cinn.	O. term.	E. banksi	Tars. spec.	B. obov.
Giza										
March	0	0	0	0	0	15.0	0	0	0	0
April	1	0	0	0	0	14.2	0	0	0	0
May	5.5	0	0	0	0	36.7	0	0	0	0
June	39.0	3	0	0	0	22.0	1	0	0	0
July	7.5	2.5	1.5	0.5	0	63.2	3	1.5	0.2	0
August	9.7	0.7	4.2	1.7	2	27.0	0.2	0.5	1.5	1
September	7.5	0	0	1	1.5	0	0	0	0	0
Abou-Hammad										
April	0	0	0	0	0	0.5	0	0	0	0
May	3	0	0	0	0	0	0	0	0	0
June	7	3	0	0	0	4.6	1.3	0	0	0
July	4.5	4	1	0.2	0	49.0	11.2	1.5	1.2	0
August	6	4	1.5	0.5	1	31.0	2.6	6	3	2.3
September	4.5	0	0	1	5	9	0	12.0	4	4

Tetranychus cinnabarinus (Bois.): A most injurious mite to Egyptian cotton plants. Its population was always the highest. It infests cotton from March to September. It congregates more frequently in colonies covered with web on the lower surfaces of the leaves.

Oligonychus terminalis Sayed: This mite appears on cotton three months later than *Tetranychus cinnabarinus*. Its infestation is noticed during June and July, but in a very low population as compared with *T. cinnabarinus*. It also prefers the lower surfaces of the leaves.

Eutetranychus banksi (McG.) (=*Anychus orientalis* (Zacher)): This mite appears on cotton fields during July and August infesting both surfaces of the leaves. It has been reported by SAYED (1946), as *Anychus orientalis*, to infest only citrus trees, *Ricinus communis* L. and some ornamental trees.

TABLE II

Monthly population means of the spider mites T. cinnabarinus, O. terminalis, E. banksi, Tarsonemus spec., *and* B. obovatus *separately on cotton plants in fields not treated with insecticides* (Itiah El-Baroud and Sakha, 1957).

Months	T. cinn.	O. term.	E. banksi	Tars. spec.	B. obov.
Itiah El-Baroud					
May	0	0	0	0	0
June	2.2	0	0	0	0
July	117.7	16	0.8	2	0
August	80.8	7	8.4	3	3.2
September	5	0	0	0	1
Sakha					
April	0	0	0	0	0
May	0	0	0	0	0
June	1	0	0	0	0
July	11	1	0	0.3	0
August	13	0.5	1.5	3	4.5
September	5	0	1	3	5

Brevipalpus obovatus Donnadieu (=*B. inornatus* (Banks)): This mite infests cotton during August and September and feeds mostly on the lower surfaces of the leaves. ATTIAH (1956) reported its infestation to *Pyrus communis*, *Pyrus cydonia* and some ornamental plants as *Populus delloides*, *Germanium* spec., *Euphorbia* spec., *Buddlia* spec. and some weeds.

Tarsonemus spec.: An unidentified mite infesting cotton during July and August and feeding almost exclusively on the lower surfaces of the leaves.

2. Predators on mites found on cotton

A. Predatory insects

The following species have been identified: *Chrysopa vulgaris* (Schn.) (Chrysopidae); *Scolothrips longicornis* Pries. (Thripidae); *Orius* spec. (Anthocoridae); and *Scymnus* spec. (Coccinellidae).

B. Predatory mites

Tydeus spec. (Tydeidae); *Mediolata* spec. (Stigmacidae); *Typhlodromus reticulatus* (Phytoseiidae); and *Anystis* spec. (Anystidae).

3. Natural infestation in the fields of the experiments

The course of natural infestation of cotton by the red spider mites was studied in Giza and Abou-Hammad (Sharkia) during the season of 1956. In the

season 1957 two other regions, Itiah El-Baroud (Beheira) and Sakha (Kafr El-Sheikh), were added. In each one of these regions one acre under cotton was left without any treatment with insecticides or acaricides for this study. Population counts of phytophagus mites were made at 7-14 days intervals throughout the whole season. The infestation indices of the total numbers of all the species are shown graphically in Figures 1 and 2. From these Figures the following deductions could be presented:

A. Variation of infestation from season to season

By comparing the infestation records at Giza and Abou-Hammad in two successive seasons (see Fig. 1 and 2), it appears that the degree of mite infestation in 1956 was considerably lighter than in 1957. The maximum indices in 1956 was 17 in Abou-Hammad and 46 in Giza, whereas in 1957 they were 101 in Abou-Hammad and 163 in Giza.

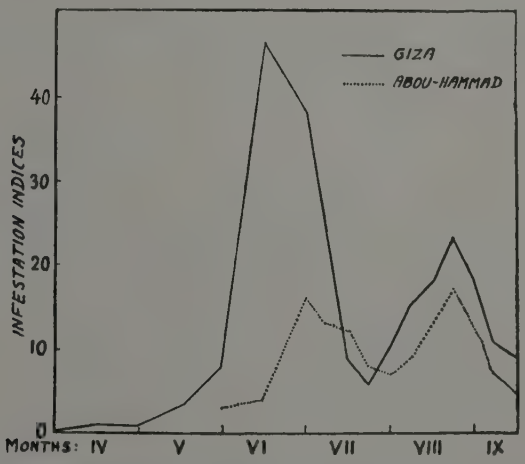

FIG. 1: Changes of red spider mites population on untreated cotton plants in Giza and Abou-Hammad, during 1956.

In 1956, two peaks of red spider population occurred. The first peak was reached in Giza at about the 15th of June and then declined and ended at about the 22nd of July. The second peak was reached at about the 24th of August. In Abou-Hammad, the first peak was reached at about the 26th of June and the second at about the 21st of August (Fig. 1). In 1957, also two peaks of red spider mite population occurred in Giza. The first peak occurred during May and the second peak during July. At Abou-Hammad only one peak occurred during July and reached its climax at about the 17th.

B. Variation of infestation from region to region

In 1957, if counts of red spider mites in the four regions are compared, these regions could be arranged in a descendent order according to the spider mites population density as follows: Itiah El-Baroud, Giza, Abou-Hammad and Sakha. The maximum infestation indices were 307 in Itiah El Baroud, 163 in Giza, 101 in Abou-Hammad and 29 in Sakha (Fig. 2).

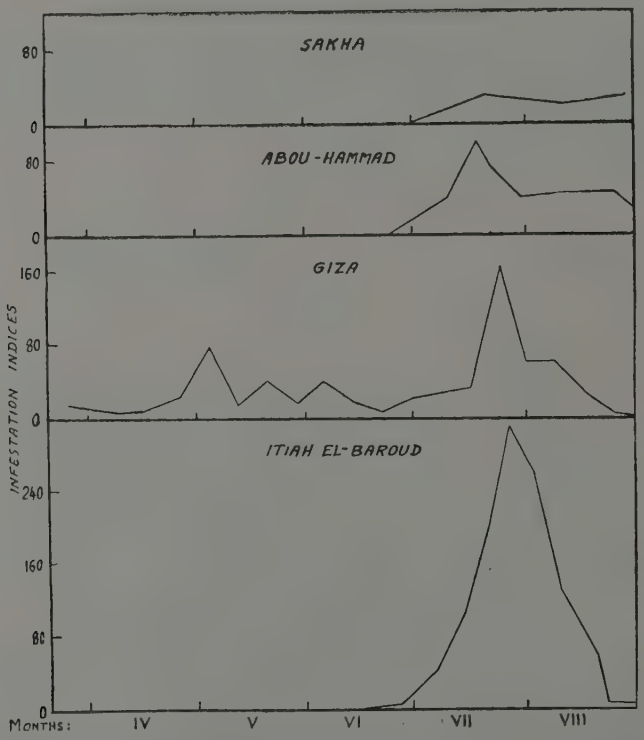

FIG. 2: Changes in red spider mites population in untreated cotton fields in Itiah El-Baroud, Giza, Abou-Hammad and Sakha, during 1957.

C. Variation in the start of infestation in the different regions

The results indicate that the red spider infestation starts in different dates in the different regions. In 1957, for example, the infestation started in Giza during March, whereas in the other regions it started during June.

IV. DISCUSSION

According to McGregor and McDonough (1917), Ugarov and Yrapob (1937), smith and Bryan (1951), Pritchard and Baker (1953), and Robertson and Arant (1956), the following spider mites have been recorded as pests of cotton in different parts of the world: *Tetranychus bimaculatus* Harvey, *Septanychus tumidus* Banks, *S. texasoma* McGregor, *Tetranychus* (*Eutetranychus*) *turkestani*, *Tetranychus atlanticus* McG., *T. pacificus* McG., *Petrobia latens* (Müller), *Paratetranychus peruvianus* McGregor, *P. macgregori* Pritchard and Baker, *Tetranychus schoenei* McGregor, *T. canadensis* McGregor. *T. marianae* McGregor, *T. desertorum* Banks and *T. telarius* (L.).

In Egypt, Willcocks and Bahgat (1937) considered the common red spider on cotton as *Tetranychus telarius* (L.) and added that other species or different strains might also be found. Sayed (1946) identified the common red spider as *Eotetranychus cucurbitacearum* Sayed. The biology of this mite was studied by Hassan and Zaher (1956). During the course of this study, it was possible to identify the following species on cotton in different localities in Egypt: *Tetranychus cinnabarinus* (Bois.), *Eutetranychus banksi* (McG.), *Oligonychus terminalis* Sayed, *Brevipalpus obovatus* Donnadieu and *Tarsonemus* spec. None of these five mites has been mentioned by Pritchard and Baker (1953) in their guide to the spider mites of cotton in America.

It is worth noting that neither of the names *Tetranychus telarius* (L.) nor *Eotetranychus cucurbitacearum* Sayed has been given by Baker, who is responsible for identification given here to any of the species found. The first name has long been used for the most common red spider in Egypt, and the second was considered by Sayed (1946) to be a new species and the most common species in Egypt. Pritchard and Baker (1955) considered the name *Tetranychus telarius* (Linnaeus) a polytypic species represented by at least several subspecies or species, among which they mentioned *Acarus cinnabarinus* (Bois.) and *Eotetranychus cucurbitacearum* Sayed.

According to the results of the present work these five mites were found to vary in the time of appearance and the degree of their infestation to cotton. They all infest cotton in the regions studied: Giza, Abou-Hammad, Itiah El-Baroud and Sakha.

As to predators, a review of literature shows the recording of a great variety of insect and mite species (McGregor, 1912, and 1917), and Yakhontov and Axohtob (1936). The insect species are: *Scolothrips sexmaculatus* Preg., *Scolothrips acariphagous* Yakh., small Coccinellid beetles, *Triphleps* spec., *Geocoris* spec., *Chrysopa* spec., and Syrphid larvae. The predaceous mites are: *Seiulus* spec., *Anystis agilis* Banks, *Scirus longirostris* Herm., and *Cheletogenes ornatus* (C. and F.).

In Egypt, Willcocks and Bahgat (1937) mentioned species of insects belonging to the genus *Triphleps* as the only important predators of the red spider

in cotton fields. They added that these insects destroy all the stages of mites. PRIESNER (1950) found *Scolothrips longicornis* Pries. as an enemy to mites of family Tetranychidae. They found it on *Citrullus* spec. feeding upon *Eotetranychus cucurbitacearum* Sayed. HASSAN and ZAHER (1956) also, found *Scolothrips longicornis* Pries. and *Orius laevigatus* Fieb. attacking the red spider mite *Eotetranychus cucurbitacearum* Sayed.

During this work, the following different species of insects and mites have been identified as predators of spider mites in cotton fields: *Chrysopa vulgaris* (Schn.) (Chrysopidae), *Scolothrips longicornis* Pries. (Thripidae), *Orius* spec. (Anthocoridae), *Scymnus* spec. (Coccinellidae), *Mediolata* spec. (Stigmaeidae), *Typhlodromus reticulatus* (Phytoseiidae), *Anystis* spec. (Anystidae), and *Tydeus* spec. (Tydeidae). BAKER and WHARTON (1952) stated that mites of the family Tydeidae are worldwide in distribution, and appear to be predaceous on small insects and mites and their eggs.

V. SUMMARY

The following five species of mites were found to infest cotton in the regions of Giza, Abou-Hammad, Itiah El-Baroud and Sakha: *Tetranychus cinnabarinus* (Bois.), *Oligonychus terminalis* Sayed, *Eutetranychus banksi* (McG.), *Brevipalpus obovatus* Donn. and *Tarsonemus* spec. The predators found associated with these mites were: *Chrysopa vulgaris* (Schn.), *Scolothrips longicornis* (Pries.), *Orius* spec., *Scymnus* spec., *Mediolata* spec., *Typhlodromus reticulatus*, *Anystis* spec., and *Tydeus* spec.

The trends of natural infestation with these mites in the above regions were studied. The results revealed variations in the degree of infestation from season to season and from region to region. The different species of mites varied according to their importance and to the time of their appearance on cotton plants. *Tetranychus cinnabarinus* (Bois.) is the most important species in all the regions. It appears in cotton fields from March until the end of the season. The other species arranged according to their importance are: *Oligonychus terminalis* Sayed, *Eutetranychus banksi* (McG.), *Brevipalpus obovatus* Donn. and *Tarsonemus* spec. They all appear late in the season starting from June.

VI. ACKNOWLEDGMENT

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INFESTATION OF COTTON WITH SPIDER MITES

[*Acarina*]

PART II: CHANGES OF SPIDER MITES POPULATION ON COTTON SEEDLINGS AFTER TREATMENT WITH SOME SYNTHETIC ORGANIC INSECTICIDES

(with 2 Text-Figures and 2 Tables)

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CONTENTS

I. Introduction. — II. Experimental design and materials. — III. Methods of spraying and counting. — IV. Results. — V. Discussion. — VI. Summary. — VII. Acknowledgment. — VIII. References.

I. INTRODUCTION

Infestation of cotton with spider mites has long been considered light and sporadic. With the increasing use of DDT and other synthetic organic insecticides for the control of cotton pests, heavy mite infestations following applications of these insecticides have been reported from many parts of the world where cotton is grown (NEWSON and SMITH, 1949, GAINES and YOUNG, 1948, and CAMPBELL and HUTCHINS, 1952).

In Egypt, the mite problem of cotton has also become acute in recent years because of the same reason. In view of this situation, a study of the effectiveness of commonly used insecticides on mite population trends in cotton fields, has been felt to be of considerable practical value.

As known, cotton is infested with two sets of pests: the early-season and the late-season pests. Two different programs of chemical control are recommended for these two sets. With these points in mind it was thought convenient to divide such a study into two phases. The present study deals with the effects during the early-season period, and those of the late season period will be the subject of the third communication in this series.

This work has been carried out in the Farm of the Faculty of Agriculture, Cairo University, during 1956 and 1957.

II. EXPERIMENTAL DESIGN AND MATERIALS

1. Experiments of 1956

In the season of 1956, the experiments were carried out in a two and half acres field under cotton. This field was divided into ten plots (numbered 1 to 10) of one quarter acre each. Each one of these plots was sprayed with the respective insecticide according to the order listed below, leaving plot No. 8 without treatment as a check. The rates of dilution were chosen according to the recommendation of the producers.

(1) Folidol (E605): an emulsible concentrate containing 46.7% diethyl paranitrophenyl thiophosphate, used at a dilution of 50 cc. per 100 litres of water.

(2) Gusathion: an emulsible concentrate containing 20% of 0,0 dimethyl-S-(4-OXO-3H-1,2,3, Benzotrizine-B-methyl)-phosphorodithioate, used at a dilution of 200 cc. per 100 litres of water.

(3) Metasystox: an emulsible concentrate containing 50% of 0,0-dimethyl-thiophosphoric-OCB-3-ethyl) ethyl-ester, used at a dilution of 100 cc. per 100 litres of water.

(4) Chlorthion: an emulsible concentrate containing 50% O-C_3-Chloro-4-nitrophenyl), 0,0-dimethyl-thiophosphate, used at a dilution of 100 cc. per 100 litres of water.

(5) Nicotine-sulphate (40%) diluted in the proportion of 150 cc. per 100 litres of water that contained one pound of soft soap.

(6) Gammalin: an emulsible concentrate containing 20% of gamma isomer of BHC, used at a dilution of 50 cc. per 100 litres of water.

(7) Diptrex: an emulsible concentrate containing 50% 0,0-dimethyl 1-2, 2,2,-trichloro-1-hydroxy-ethylphosphonate, used at a dilution of 100 cc. per 100 litres of water.

(8) Agrocide: a dispersable powder containing 6.5% gamma isomer of BHC, used at a dilution of 500 grams per 100 litres of water.

(9) Dieldrix 15: an emulsible oil solution containing 18.6% technical Dieldrin, diluted in two proportions: 750 cc. and 500 cc. per 100 litres of water.

A total of three sprayings were made; the first took place on March 26th, the second two weeks later, i.e., on April 11th, and the third three weeks after the second, i.e., on May 2nd. In plot No. 10 the second spraying was ommited.

2. Experiments of 1957

A. Spraying experiments

These experiments were carried out in a two acres field under cotton, divided into 10 plots of one fifth acre each. Plots Nos. 1 to 7 were sprayed three times with the respective insecticide according to the order listed below. The three sprayings were carried out on April 2nd, April 25th and May 18th.

(1) Toxaphene emulsion concentrate containing 60% actual Toxaphene and 6% emulsifier, used at a dilution of 1 litre per 100 litres.

(2) Gusathion: used at a dilution of 200 cc. per 100 litres.

(3) DDT+Lindane emulsion: an emulsion concentrate containing 30% DDT and 9% Lindane, used at a dilution of 110 cc. per 100 litres.

(4) Gammalin: used at a dilution of 100 cc. per 100 litres.

(5) HOE 2671: an emulsion concentrate containing 20% of Hexachloroendomethylen-bis-cyclohepten-bis (oxymethylen) sulfit, 70% zylol and 10% oxethylated alcylphenol as a sticking material, used at a dilution of 200 cc. per 100 litres of water.

(6) Metasystox: used at a dilution of 100 cc. per 100 litres.

(7) Dieldrin: wettable powder containing 50% actual Dieldrin, used at a dilution of 200 grams per 100 litres.

B. Seed treatment experiments

The following two seed powders were used, each at three rates:

(1) Disyston, a seed powder containing 50% phosphorodithioic acid S-2 (ethylthio) ethyl 0,0-diethyl ester and activated carbon as the carrier, used at 6, 8 and 10 kgs. per 100 kgs of seeds.

(2) Thimet 44-D, a powder containing 44% actual Thimet (0,0, diethyl S-(ethylthiomethyl) phosphorodithioate) and 2% methylcellulose, used at 6, 8 and 10 kgs. per 100 kgs. of seeds.

These experiments were carried out in a two acres field. Out of this field, only two plots, one quarter acre each, and which were given the numbers 1 and 2, were cultivated with treated seeds and the rest of the field was left as control. Each one of these two plots was divided into three sections and treated at three rates.

III. METHODS OF SPRAYING AND COUNTING

Spraying of the insecticides was carried out by the use of the usual knapsack compressed air sprayers equipped with hollow cone nozzles. All the diluted

preparations were used at the rate of 150 litres per acre. The technique of treating the seeds with Thimet 44-D and Disyston was as follows:

A sufficient quantity of seeds was first cleaned. Weighed lots were slightly moistened with water in order to decrease the dustiness of the finished product. Each lot was put in a cylindrical glass jar together with the weighed dose of the insecticide. The jar was then stoppered and shaken vigorously for about five minutes until the seeds were thoroughly coated. Treated seeds were sown and irrigated on the same day.

Mite population counts were carried out in samples of 20 seedlings, each according to the method described in Part I of this series (see this Bulletin, pages 357-365).

In 1956, the counts were made at week intervals and in 1957 at 1, 3, 7, 11 and 15 days after the date of each spraying. After the third spraying, 4 more counts were made at week intervals.

IV. RESULTS

1956

The spider mites population indices are arranged in Table I which shows that the numbers of mites after the first and second applications were very low and no appreciable differences appeared between treatments except in the plot which was treated with Dieldrix 15. In this plot, relatively high numbers of mites started to appear on the plants two weeks before the date of the last spraying.

In order to facilitate comparisons between the degrees of infestations in the different plots, the means of all the infestation indices were calculated for each plot separately and shown graphically in Figure 1.

After consulting Table I and Figure 1, the following results could be presented:

(1) The highest increase in spider mites population occurred in the plot treated with Dieldrix 15. This increase continued for a longer period after the last treatment than in other materials.

(2) The increase in mites population in the plot treated with Agrocide, at the dosage used, came second to Dieldrix 15.

(3) The plots treated with Metasystox and Gusathion remained free from mite infestation throughout the whole period between treatments. The increase in mites population after the 3rd treatment was very slight. Only occasional mites were found on the plants during the first four weeks after the third spraying. The population then increased but very slowly.

(4) Very few mites appeared on the plants of the plots treated with Folidol E605, Chlorthion and Diptrex during the period between the sprayings, but the build up of the population after the last spraying was faster and higher than in the cases of Metasystox and Gusathion.

TABLE 1

Changes in spider mites population on cotton seedlings sprayed with different insecticides in the season 1956.

Plot number	Insecticidal formulation	Rate of dilution per 100 litres	Red Spider Mite infestation indices													
			After 1st Spraying on March 26th,		After 2nd Spraying on April 11th.			After 3rd. spraying on May 2nd.								
			2/4	9/4	18/4	25/4	1/5	9/5	16/5	23/5	30/5	6/6	13/6	20/6	27/6	4/7
1	Folidol	50 cc.	1	2	3	6	9	6	9	13	50	93	70	47	34	24
2	Gusathion	20 cc.	0	0	0	0	0	0	4	6	10	17	31	40	38	70
3	Metasystox	100 cc.	0	0	0	0	0	0	2	5	9	13	19	26	33	37
4	Chlorthion	100 cc.	1	2	1	2	3	2	16	32	67	111	83	59	32	50
5	Nicotine sulphate .	150 cc.	1	1	2	3	5	5	8	19	32	48	52	64	64	62
6	Gammalin	50 cc.	1	1	0	1	6	8	26	51	90	126	94	59	47	36
7	Diptrex	100 cc.	1	2	1	2	8	11	17	27	57	93	94	94	61	36
8	Check		1	2	3	7	9	9	14	23	36	55	50	47	34	21
9	Agrocide	500 gr.	0	0	1	3	10	15	64	120	129	143	125	113	69	37
10	Dieldrix	750 cc.	1	1	1	16	47	—	—	—	—	—	—	—	—	—
	:	500 cc.	—	—	—	—	—	66	293	568	558	543	379	211	190	183

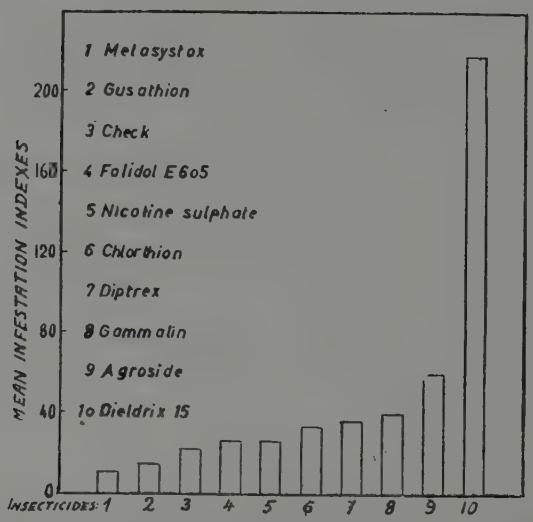

FIG. 1: The calculated means of spider mites population indices on cotton seedlings sprayed with different insecticides (1956)

(5) In the plot treated with Nicotine sulphate, the trend of the mites population was nearly the same as in the check plot, either between the sprayings or after the third one.

(6) In the Gammalin plot, the mite population was higher than in the check plot.

1957

A. Spraying experiments

The spider mites population records gathered after each of the three sprayings are recorded in Table II. From this Table, the following deductions could be presented:

(1) After the first spraying, Metasystox, Gusathion, HOE 2671 and Gammalin, were effective in reducing the red spider mites population. In the case of Dieldrin and DDT + Lindane, there was some increase in the population. In the plot treated with Toxaphene, there was an initial reduction for about 10 days followed by an increase until the date of the second spraying.

(2) After the second spraying, Metasystox and Gusathion were also successful in decreasing the spider mites population. In all the other plots, there was an initial decrease in variable degrees as indicated by the count made in all the plots one day after the spraying. This decrease was then followed by variable degrees of increase, the Toxaphene and Dieldrin being the highest of all.

TABLE II. — *Changes in spider mites population on Cotton seedlings sprayed with different insecticides.*

Red Spider mites infestation indices

Insecticidal formulation	Percentage of active ingredients	Rate of dilution per 100 litres	Dates after 1st application (2/4)						Dates after 2nd application (25/4)					
			3/4	5/4	9/4	13/4	17/4	24/4	26 4	28/4	2/5	6/5	10/5	17/5
Toxaphene E.C.	60	1000 cc.	0	3	3	2	13	29	12	66	173	184	872	1133
Gusathion E.C.	20	200 cc.	0	3	7	0	1	5	0	81	85	88	101	178
DDT (30%) + Lindane	9	110 cc.	8	13	12	20	20	21	24	200	190	320	350	619
Check	—	—	7	10	8	17	17	16	35	99	150	133	128	105
Gammalin E.C.	20	100 cc.	2	4	5	5	7	7	26	96	145	186	200	842
HOE 2671 E.C.	20	200 cc.	0	7	2	4	6	10	5	140	259	269	277	334
Metasystox E.C.	50	100 cc.	0	0	0	0	3	5	0	4	4	5	15	19
Dieldrin W.P.	50	200 grs.	15	17	20	21	36	27	18	125	173	249	331	1130

Insecticidal formulation	Percentage of active ingredients	Rate of dilution per 100 litres	Dates after 3rd application (18/5)								
			19/5	21/5	25 5	29/5	2/6	9/6	16/6	23/6	30 6
Toxaphene E.C.	60	1000 cc.	779	2291	1542	1638	3400	4833	3466	2325	800
Gusathion E.C.	20	200 cc.	12	16	28	36	39	34	30	37	46
DDT (30%) + Lindane	9	110 cc.	347	269	106	88	107	117	103	93	70
Check	—	—	69	12	12	26	182	93	49	40	64
Gammalin E.C.	20	100 cc.	90	95	38	32	24	16	5	7	10
HOE 2671 E.C.	20	200 cc.	122	224	236	298	163	60	60	67	90
Metasystox E.C.	50	100 cc.	0	3	7	3	2	3	4	6	7
Dieldrin W.P.	50	200 grs.	795	1433	1214	1342	3971	5660	4036	1687	610

E.C. = Emulsion concentrate; W.P. = Wattable powder.

(3) After the third treatment, the red spider mite increased considerably in the plots treated with Toxaphene and Dieldrin and the symptoms of spider mites infestation were very clear on the plants. Metasystox gave also the best results in decreasing the degree of infestation. Gusathion and Gammalin caused only slight reduction. HOE 2671, DDT + Lindane caused an increase in the population but at a lower degree than Dieldrin and Toxaphene.

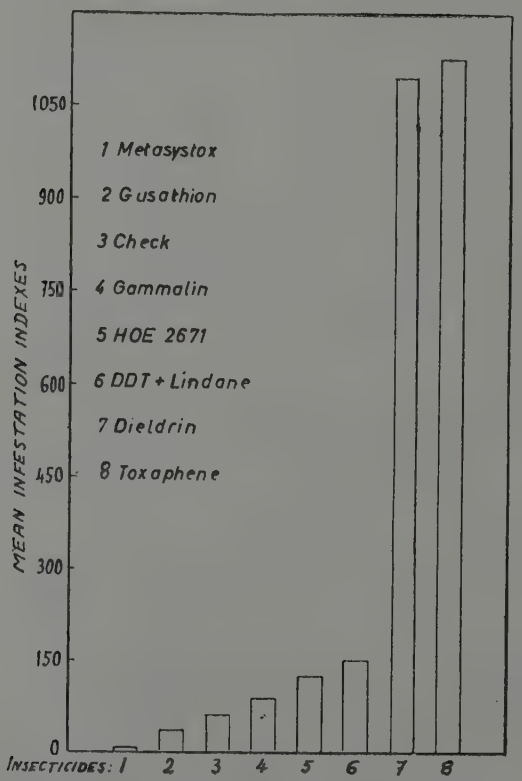

FIG. 2: The calculated means of red spider mites population indices on cotton seedlings sprayed with different insecticides (1957).

The means of the population records of the whole period of the experiment from 1st spraying till six weeks after the third spraying are shown graphically in Figure 2 which reveals the considerable difference between both Dieldrin and Toxaphene and the rest of the insecticides.

B. Seed treatment experiments

The two insecticides used for seed treatments, Thimet 44-D and Disyston, showed high acaricidal efficiency even with the lowest rates used. In plots treated with Thimet 44-D the seedlings remained free from infestation with spider mites for six weeks, i.e., from March 17th, the date of complete emergence of plants till 27th April.

Starting from the first of May, the mites began to appear in very low numbers as compared with the numbers found on the untreated plants of the control plot. The three rates used seemed to give no appreciable difference on the results.

In the plots treated with Disyston, the seedlings also remained free from infestation with the red spider mite for eight weeks, i.e., from March 17th, the date of complete emergence of plants, till May 13th. After that date onwards, few numbers of the red spider mites began to appear on the plants emerging from seeds treated with the lowest rate. In the other two sections, the infestation started to appear one or two weeks later.

V. DISCUSSION

The systemic insecticide Metasystox, at a concentration of 100 cc. per 100 litres, was found to be the best of all the liquid materials tested, in reducing the spider mite infestation on cotton seedlings. Gusathion, at a concentration of 200 cc. per 100 litres, also gave about the same results as Metasystox. Besides being effective on mites, these two materials were also found highly effective against other early-season cotton insect pests, particularly cotton thrips (El Nahal, 1958). The other three phosphorous insecticides, Folidol E605 at a dilution of 50 cc. per 100 litres, Chlrothion at a dilution of 100 cc. per 100 litres and Dipterex at a dilution of 100 cc. per 100 litres, were less effective and the build up of the population of mites on cotton seedlings following treatments with those materials was faster and higher than with Metasystox and Gusathion.

The use of Dieldrin, Agrocide, Toxaphene, DDT + Lindane and HOE 2671 was always followed by variable increase in mites population. This effect could be attributed to two reasons: (1) the acaricidal effect of these insecticides, if there is any, is very weak when compared with Metasystox and Gusathion; (2) the use of these insecticides might affect the natural equilibrium between the population of spider mites and the population of their predators. No counts of predators have been taken in this study, but as will be shown in the third communication of this series, the effect of certain insecticides on the population of mite predators is an important factor responsible for the increase of mites population on cotton after the use of these insecticides.

The above findings are supported by the findings of other workers on the same problem. Young (1948) found that both BHC and Toxaphene permitted

an increase of the two spotted spider mite after applications for controlling the boll weevil and cotton aphid. IVY and SCALES (1950), indicated that spider mites, *Septanychus* spec., was not killed by 2.5% concentration of Dieldrin. They added also that the possibility of spider mite build-up after field applications with this material, therefore, should not be overlooked.

The results of seed treatment experiments with Thimet 44-D and Disyston, indicate that this method is very promising for the control of spider mites infesting cotton seedlings. The results also indicate that there was no appreciable difference between the three rates used for each one. According to the Annual Report of Conference on Cotton Insect Research and Control, Memphis, Tenn., 1955, Thimet in laboratory killed spider mites for 4-9 weeks following emergence of the plants. REYNOLDS et al (1957) demonstrated the high effectiveness of both Thimet and Disyston on spider mites in greenhouse experiments in which cotton plants were artificially infested with *Tetranychus cinnabarinus* (Bois.) one of the species that infest cotton in Egypt.

VI. SUMMARY

The following liquid insecticidal formulations, which are used for the control of early season cotton pests, were evaluated from the point of view of their effect in changing the spider mites population on cotton seedlings: Folidol E 605, Chlorthion, Dipterex, Gusathion, Gammalin, Agrocide, Nicotine sulphate, Dieldrix 15, HOE 2671, Toxaphene and DDT+Lindane. Also two systemic insecticides formulated as powders for seed treatment, Thimet 44-D and Disyston, each used in three rates, were evaluated.

The results indicated that Metasystox and Gusathion at rate of 100 cc. per 100 litres and 200 cc. per 100 litres, respectively, proved to be the most effective liquid materials causing considerable reduction in spider mites population. The use of Dieldrin, Agrocide, Toxaphene, DDT + Lindane and HOE 2671 was always followed with variable build up in mites population. Folidol E 605, Chlorthion, Nicotine sulphate, Gammalin and Dipterex showed no appreciable effect.

The two seed powders Thimet 44-D and Disyston at the three rates used were found to be highly effective against the mites for about 6-8 weeks from the emergence of the plants.

VII. ACKNOWLEDGMENT

This investigation forms a part of the program of work in the Department of Plant Protection, Faculty of Agriculture, Cairo University. The authors are indebted to Messrs. THABET Brothers, SHELL Chemicals and HOMSY for supplying the insecticides used in this work.

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INFESTATION OF COTTON WITH SPIDER MITES

[*Acarina*]

PART III: CHANGES OF POPULATION OF SPIDER MITES AND THEIR PREDATORS AFTER THE USE OF CERTAIN INSECTICIDES FOR THE CONTROL OF LATE-SEASON COTTON PESTS

(with 5 Tables)

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CONTENTS

I. Introduction. — II. Materials and Methods — III. Experimental design. — IV. Results. — V. Discussion. — VI. Summary. — VII. Acknowledgment. — VIII. References.

I. INTRODUCTION

In Part II of this series (see this Bulletin, pages 367-377), the authors reported on the results of field experiments in which the effect of spraying with different insecticides on changing the population of spider mites on cotton seedlings, was studied. The contents of the present article represent the results of further studies on spider mites populations after spraying fully grown cotton plants with certain insecticides for the purpose of controlling the cotton leaf worm, *Prodenia litura* F., and the two boll worms, *Earias insulana* Boisd. and *Pectinophora gossypiella*

Saund. The insecticides tested are: Toxaphene, Dieldrin, DDT + Lindane and Gusathion. These insecticides, all in liquid formulations, were chosen because they are available and commonly used by cotton growers in this country.

The effect of the above insecticides on the population of the predators of spider mites was also studied. All results were submitted to statistical analysis in order to determine the effects of the main factors, and to reveal the relations, if any, between them.

This work has been carried out during 1956 and 1957 in fields which were not treated with insecticides in the early-season period to eliminate any effects, if these insecticides on the initial infestation with mites at the start of these experiments.

II. MATERIALS AND METHODS

A. Insecticides

The insecticides used are given in the following Table:

Insecticides	Form of product	Active ingredient	Percentage of active ingredient	Quantity of product per acre
Toxaphene	E.C.*	Actual Toxaphene	60	3.5 litres
DDT+Lindane	E.C.	DDT + Lindane	30 DDT+9 Lindane	2.5 ,,
Gusathion	E.C.	**	20	2.0 ,,
Dieldrin	E.C.	Actual Dieldrin	20	2.25 ,,
Dieldrin	W.P.***	,, ,,	50	750 grams

* = 0,0-dimethyl-S-(4-0 × 0-1,2,3, Benzotriazine-3-m thyl) phosphorodithioate ; ** E.C. = Emulsion concentrate; *** W.P. = Wettable powd.r.

B. Technique of spraying

The usual Knapsack compressed air sprayers, each equipped with a T-shaped spraying rod on which 6 hollow cone-type nozzles known as "D wiker 2", 40 cm. apart were mounted, were used for spraying. These nozzles are of the "low gallonage" or "low-volume" type which convert the liquid into a finely divided spray. By these sprayers four rows of cotton were sprayed simultaneously. The height of the boom was adjusted at a level about 30 cms. above the tops of the plants. All sprays were used at a rate of approximately 70-80 litres of the diluted material per acre at a pressure of 4 to 10 kgs. per cubic centimetre.

III. EXPERIMENTAL DESIGN

1. Experiments of 1956

A small-plot experiment was conducted in a two acres field cultivated with the Ashmouny variety cotton. The field was divided into 25 small plots of 0.08

acre each. Each one of the four liquid insecticidal formulations given in the above Table was used in five plots chosen according to a latin square design. Five plots were left untreated as control. Dieldrin was used in this season in the form of a wettable powder.

Two sprayings only were made, the first being on July 30th and the second on August 12th. Samples of cotton leaves from each plot were taken for population counts at weekly intervals after the second application till the end of the season.

2. Experiments of 1957

A two acres field, under Ashmouny variety cotton was divided into 20 plots of 0.1 acre each, arranged in randomized blocks with four replicates for each of the four liquid insecticidal formulations. Four replicates were left as control. Dieldrin was used in this season in the form of an emulsifiable concentrate.

A total of four sprayings at about 20 days intervals were made during the period from June 15th to August 30th. The dates of sprayings were: June 15th, July 5th, July 25th, and August 14th. Samples were taken for population counts at the 1st, 3rd, 7th, 12th and 19th days after the date of each spraying. Results of treatments were estimated by counting the red spider mites and their predators on representative samples of 20 cotton leaves. The technique of counting and estimating the population indices is described in Part I of this series (see this Bulletin, pages 357-365).

IV. RESULTS

1956

The averages infestation indices of the spider mites and their predators for the five replicates of each insecticidal spray and for the six counts made during a period of six weeks after spraying for the second time are arranged in Table I.

The results showed that the population in all plots was not even throughout the whole period of the experiment, but it always started at a low level, increased to a maximum and then declined. Also the trend of the population of spider mites in all plots was not the same. The increase in mite population began in the plot treated with Toxaphene earlier than in the other plots. In the case of Gusathion, the population increased at a relatively low rate for about two weeks after which the rate of increase was relatively higher.

As expected, the statistical analysis revealed that the different insecticides exerted significant effects on the populations of the spider mites and their predators. The following remarks could be presented:

(1) There was no significant difference between the spider mite population in the plots sprayed with Gusathion and the check plots during the first two weeks after the date of the 2nd spraying. Then, there was a significant increase for a pe-

riod of about three weeks, after which the population began to decline without significant difference when compared with the control.

(2) The DDT + Lindane is the second in effect after Gusathion. During the first three weeks, the population of the spider mites in the plots treated with this product increased significantly. Later, the population declined but continued to be higher, although not significant, than in the checks.

(3) In the cases of Toxaphene and Dieldrin, there was considerable increase in the population of mites during most of the period in which the records were taken. The differences between the population in the plots treated with any one of these two materials and the check plots were highly significant during the first four weeks but during the last two weeks the difference was significant.

(4) The materials compared one with the other could be arranged in a descending order according to their effect in increasing the spider mite population as follows: Toxaphene, Dieldrin, DDT + Lindane and Gusathion.

(5) All the insecticides used reduced the population of the predators for 4-5 weeks after the date of the second spraying. After that period the population of predators in the whole field of the experiment was nearly even.

Whether there is any relation between this reduction in the population of predators and the changes of spider mites population was ascertained by calculating the correlation coefficient. A negative significant correlation at 99% level of probability was found between those two varieties (C.C.-O.495 $<$ 0.208), indicating that the decrease in predators numbers in the fields is a main reason for the increase in mites population after treatment with insecticides.

1957

The means of the population indices of the spider mites and their predators of the four replicates determined after each one of the four sprayings are recorded in Tables II-V. An analysis of variance was made for each set of records and further analyses were also made to obtain the L.S.D. as shown in the Tables. The important conclusions that could be drawn from this statistical analysis are as follows:

(1) *The effect of insecticides*: In general, the population of spider mites increased significantly after spraying with Dieldrin, Toxaphene and DDT + Lindane, whereas no significant increase occurred after the use of Gusathion. The means of infestation indices throughout the whole period of the experiment for the plots treated with the different insecticides in the above order and the check plots, respectively, are 440, 398, 337, 88 and 90. These results are in accord with the results of the previous season.

As regard predators, the insecticides also reduced their population variably. The means of predators indices for the four insecticides Dieldrin, Toxaphene, DDT + Lindane and Gusathion, and the check plots are 8, 4.1, 3.6, 9.7 and 11.1, respectively. It appears that DDT + Lindane gave the highest effect in reducing

TABLE I

The population of red spider mites and their predators on cotton plants after spraying with Toxaphene, DDT + Lindane, Gusathion and Dieldrin (1956)

Treatment	Population indices of predators							Infestation indices of red spider mites						
	Weeks after the date of 2nd application							Weeks after the date of 2nd application						
	1	2	3	4	5	6	Average	1	2	3	4	5	6	Average
Toxaphene	1.1	0.60	1.58	4.75	6.60	8.56	3.87	63.8	149.6	211.6	112.2	15.0	2.6	92.46
DDT + Lindane	2.9	2.08	1.94	3.66	4.36	7.88	3.80	69.8	53.6	127.2	75.4	38.8	11.8	62.76
Gusathion	2.7	0.94	1.22	1.42	3.22	7.64	2.52	7.0	29.8	92.4	84.8	92.2	25.6	55.3
Dieldrin	2.3	1.78	1.24	3.94	5.62	7.68	3.76	49.8	87.4	230.4	101.4	26.6	15.8	85.23
Untreated	5.1	3.78	3.48	4.20	5.48	7.12	4.86	12.4	26.8	46.2	52.0	39.4	10.2	31.16

L.S.D. at 95% level	Treatments T.	0.18	24.97
	Date of sampling D.	0.21	27.41
	Interaction T × L.	1.07	61.44

All the records in this Table are averages of 5 replicates.

TABLE II. — *The population of red spider mites and their predators on cotton plants after 1st application carried out on June 15th, with Toxaphene DDT + Lindane, Gusathion and Dieldrin (1957).*

Treatment	Population indices of predators						Infestation indices of red spider mites					
	Days after 1st application						Days after 1st application					
	1	3	7	12	19	Average	1	3	7	12	19	Average
Toxaphene	0	0	0	0	0.17	0.03	20.25	20.5	48.5	76.25	304.2	93.95
DDT + Lindane	0	0	0	0	0	0	107.5	55.0	32.25	50.0	325.7	114.1
Gusathion	0	0	0	0.1	0.55	0.13	1.75	12.75	16.25	22.75	141.2	38.95
Dieldrin	0	0	0	0	0	0	39.0	19.75	42.25	164.25	609.3	174.9
Untreated	2.47	2.77	3.0	3.52	5.62	3.47	8.0	33.25	27.5	47.75	158.0	31.6

L.S.D. at 95% level; insecticides — date of sampling 0.22 100

All the records in this and the following Tables are averages of 4 replicates

TABLE III. — *The population of red spider mites and their predators on cotton plants after 2nd application carried out on July 5th, with Toxaphene, DDT + Lindane, Gusathion and Dieldrin (1957).*

Treatment	Population indices of predators						Infestation indices of red spider mites					
	Days after 2nd application						Days after 2nd application					
	1	3	7	12	19	Average	1	3	7	12	19	Average
Toxaphene	0	0	0	0	2.15	0.43	377	392	616	1220	1645	850
DDT + Lindane	0	0	0	0.27	0.52	0.16	250	785	1369	2104	1382	1178
Gusathion	0	0	0	0.47	0.87	0.27	55	72	94	123	805	287
Dieldrin	0	0	0	0	0.77	0.15	674	1211	1425	1777	2169	1451
Untreated	4.5	4.77	5.42	4.5	4.75	4.75	135	175	188	304	374	235

L.S.D. at 95% level, insecticides — date of sampling 0.42 557

TABLE IV. — *The population of red spider mites and their predators on coton plants after 3rd application, carried out on July 25th, with Toxaphene, DDT + Lindane, Gusathion and Dieldrin (1957).*

Treatment	Population indices of predators						Infestation indices of red spider mites					
	Days after 3rd application						Days after 3rd application					
	1	3	7	12	19	Average	1	3	7	12	19	Average
Toxaphene	1.75	3.30	4.65	9.32	12.7	6.34	1702	262	4	5.74	3.50	403
DDT + Lindane	0.87	4.07	5.92	8.02	9.35	5.65	1103	162	38	7.25	1.70	262
Gusathion	1.00	2.42	3.32	5.20	8.80	4.15	78	27	9	4.50	3.70	24.6
Dieldrin	1.12	3.32	7.85	13.57	16.97	8.56	561	65	25.2	5.20	2.20	131.8
Untreated	4.20	7.12	12.77	18.62	26.37	9.81	351	71	31	5.20	2.00	92.1
L.S.D. at 95% level; insecticides — date of sampling							1.8	189				

TABLE V. — *The population of red spider mites and their predators on cotton plants after 4th application carried out on August 14th, with Toxaphene, DDT + Lindane, Gusathion and Dieldrin (1957).*

Treatment	Population indices of predators						Infestation indices of red spider mites					
	Days after 4th application						Days after 4th application					
	1	3	7	12	19	Average	1	3	7	12	19	Average
Toxaphene	3.17	4.50	6.85	12.75	21.5	9.75	2.50	0.50	0	0.75	1.75	1.10
DDT + Lindane	3.32	4.40	6.02	19.0	12.0	8.95	3.75	1.25	0	1.00	2.25	1.65
Gusathion	12.55	16.40	22.1	40.5	80.0	34.56	7.00	2.25	0	0	0	1.85
Dieldrin	9.42	15.15	24.4	30.75	38.0	23.54	7.50	2.25	0	0.50	2.25	2.50
Untreated	14.77	17.05	21.6	28.75	50.0	26.43	10.0	4.25	1.75	1.25	0.50	3.55
L.S.D. at 95% level; insecticides — date of sampling							8	1.77				

the predators population, followed by Toxaphene, Dieldrin and Gusathion. The statistical analysis also revealed a negative significant correlation between the red spider population and their predators (C.C.-0.631 $<$ 0.128).

The disagreement between the order of the effect of the insecticides on increasing the population of the spider mites and the expected effect on decreasing the population of the predators, indicates that there must be other factors responsible for the changes in mite population observed after the use of these insecticides. Of these other factors, the most obvious, according to the results of this work, is the acaricidal effect of the insecticides as will be mentioned later.

(2) *The effect of the different sprayings*: The results indicate that, there were no appreciable differences between the different materials after the first spraying. Most of the increase occurred during the period between the second and third sprayings and during few days after the third spraying.

In the case of predators, the population as a whole decreased considerably after the first and second sprayings, whereas the decrease was not so high after the third and fourth. In this respect, it should be mentioned here that most of the predators in the first period, i.e., the period between the first and the third applications were insect species, and the majority in the second period were mites species. This fact might reveal the specific action of the insecticides under test.

(3) *Dates of sampling*: The counts made one day after treatment with each insecticide, specially after the 2nd and 3rd sprayings, indicated that Gusathion caused considerable initial reduction in spider mite population. After the second and the third sprayings the reduction was 61 and 90%, respectively. This is undoubtedly due to the acaricidal effect of this insecticide. This reduction was not observed in the case of the other three materials.

As regards predators, there was a complete reduction in their population in the case of DDT + Lindane and Dieldrin, throughout the whole period between the 1st and 2nd sprayings and most of the period between the 2nd and 3rd sprayings. In the case of Toxaphene and Gusathion, the complete reduction continued for about 12 and 7 days, respectively, after the dates of the 1st and 2nd sprayings. After the third and 4th sprayings, when most of the predators were mites species, the population of the predators continued in general to increase gradually, after an initial reduction following spraying.

V. DISCUSSION

Four compounds, Toxaphene, Dieldrin, DDT + Lindane and Gusathion were tested in field experiments from the point of view of their effect on changing the population of spider mites on fully grown cotton plants. The experiments were carried out in two successive seasons, 1956 and 1957. The results of the two seasons agreed in that, the use of the first three insecticides was always followed by an inc-

rease in the spider mites population, and that this increase was associated with a reduction in the predators population. These results are in accord with the results of GAINES and YOUNG (1948), IGLINSKY and GAINES (1949), NEWSON and SMITH (1949), PARENCIA and EWING (1948) and CAMPBELL and HUTCHINS (1952). All of these workers agreed that the use of chlorinated insecticides interfere with the natural balance existing between the spider mites and their natural enemies, resulting in increasing the severity of infestation. The present results also showed that, in general, the use of Dieldrin was followed by the highest population of spider mites when compared with the other three insecticides. This was the case in the experiments of 1956 in which only two sprayings were made. But in 1957, in which four sprayings were made, Toxaphene was followed by the highest population of mites, after the 3rd spraying. The indication of such result is that the repeated use of Toxaphene results in considerable increase in mite population. This finding is of considerable importance and should be considered when recommending a program of chemical control of cotton pests by the use of this material.

Another point of interest revealed from the present work, is that the order of the effect of the insecticides on the red spider mites population differs from the expected order of the effect of the predators population. This indicates that apart from the effect of the changes in predators population due to the effect of the insecticides on mites population, other factors play an important role in this respect. The acaricidal effect of the insecticides tested could be considered as one of those factors. The use of Gusathion, for instance, was not followed by any appreciable increase in mite population, but on the contrary it was always followed by considerable reduction due, undoubtedly, to the high effect of this material on mites.

Another explanation has been given by DONALD (1952), in his studies on *Tetranychus multisetis* (McG). This author stated "it seems that there are several distinct effects of DDT on both the individual mite and on the colonies as a whole. DDT has an effect on the mites which, for lack of a better term, is called an irritating effect. Shortly after an initial contact with this chemical the mites become highly active and move rapidly and greater distances. During this period of increased activity there are very few eggs laid, and the mites become widely scattered over the host. This dispersion results in a higher reproductive potential and hence earlier mite build-up". The same author conducted some tests to determine the effects of DDT on two of the leading mite predators, *Stethorus picipes* Casey and *Orius tristicolor* (White), and found that both of these predators could be easily killed by DDT.

This indicates that the changes in red spider mites population after the use of certain insecticides is not a simple matter, but it seems to be an interrelation of several factors acting together on both mites and predators.

The results of DONALD might help in finding reasons for some facts that have resulted from the present study, as, for example, the facts that the increase in mite population usually starts after some time has elapsed from the date of ap-

plication, and that by repeating the applications, as in the case of Toxaphene, the population of spider mites increases considerably.

Lastly, the final result of this work is that in order to prevent any increase in spider mites population in cotton fields to be treated with Toxaphene, Dieldrin and DDT + Lindane, an acaricide should be combined. In the fourth paper of this series, the results of using combinations of different insecticides and different acaricides will be presented.

VI. SUMMARY

In small replicated plots field experiments, Toxaphene, Dieldrin, DDT + Lindane and Gusathion, used as sprays, were tested from the point of view of their effect on changing the spider mites populations on fully grown cotton plants.

Relatively severe infestations with the spider mites, associated with considerable reduction in its predators population, occurred after spraying with Toxaphene, Dieldrin and DDT + Lindane, whereas no appreciable increase occurred after spraying with Gusathion.

All the results were submitted to statistical analysis in order to reveal the relations between the main factors of the experiments and to enable comparisons to be made between the different treatments. The analysis revealed: (1) a negative significant correlation between the population of the spider mites and the population of their predators; (2) the changes in predators population is not the only factor responsible for the changes in mites population. The other factor that could be suggested according to the results of this work is the acaricidal effect of the insecticides. The third factor is that the effect of Toxaphene on increasing the mites population is enhanced by repeated spraying.

VII. ACKNOWLEDGMENT

This investigation forms a part of the program of work in the Department of Plant Protection, Faculty of Agriculture, Cairo University. The authors are indebted to Messrs. THABET Brothers, SHELL Chemicals and HOMSY for supplying the insecticides used in this work.

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INFESTATION OF COTTON WITH SPIDER MITES

[*Acarina*]

PART IV: THE USE OF CERTAIN ACARICIDES IN COMBINATION WITH CERTAIN INSECTICIDES FOR THE CONTROL OF THE RED SPIDER MITES INFESTING COTTON PLANTS

(with 1 Text-Figure and 5 Tables)

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CONTENTS

I. Introduction. — II. Materials and methods. — III. Experimental design. — IV. Results. — V Conclusions and discussion. — VI. Summary. — VII. Acknowledgment. — VIII. References.

I. INTRODUCTION

The increased infestation of cotton by red spider mites during recent years, following the wide use of different organic insecticides for the control of cotton insect pests, calls for accurate studies concerning the use of different acaricides in combination with the commonly used insecticides for the purpose of combating these pests together with the insect pests.

The experiments herein reported were conducted to fulfill this requirement. They were carried out during the season of 1958 in the Farm of the Faculty of Agriculture, Cairo University, at Giza. The available sulphur and phosphorous acari-

cides, Tedion, Ekatin, Meta-iso-systox and Delnav were used in combination with Toxaphene, Dieldrin and mixture of DDT+Lindane.

It should be mentioned here that the two-spotted spider mite *Tetranychus cinnabarinus* (Bois.) (*Tetranychus telarius* (L.) complex as resolved by BOUDREAUX, 1956) is the most prevalent and important pest of cotton in Egypt (see Part I in this Bulletin, pages 357-366). MISTRIC (1957) considering that *T. telarius* and *T. cinnabarinus* are two different species, mentioned that both are the most difficult species of spider mites to control on cotton (ANONYMOUS, 1955). Acaricides which are effective against these two species are also effective against most of the species attacking cotton.

II. MATERIALS AND METHODS

The acaricidal formulations used are given in Table I. They were all in liquid form.

TABLE I

Name of product	Active ingredient	Concentration of active ingredient	Rate of product per acre
Tedion	2, 4, 5, 4'-Tetrachloro-diphenyl sulphane	8%	1.5 litres
Delnav	Dithiophosphate of Dioxane	4 lb. per gallon	0.5 litres
Ekatin	Thiometon	20%	,,
Meta-iso-systox ..	Thioglycol dimethyl Phosphoric ester P=O Isomere	25%	,,

All the informations concerning the insecticidal formulations and the rates of their application per acre are given in Part III (see this Bulletin, pages 379-390). The same technique of spraying mentioned in that paper was also followed in the present experiments.

Each insecticide was used alone and in combination with each one of the above mentioned four acaricides. The number of combinations was therefore twelve.

III. EXPERIMENTAL DESIGN

A small plot experiment was conducted in 1.8 acres field under cotton. It was divided into 45 plots arranged in randomized blocks. Three plots were devoted for each treatment with any one of the 12 combinations mentioned above. Each insecticide was used alone in 3 plots. Each plot was divided lengthwise into 20 rows, about 50 cms. apart and 14 metres long.

A total of four sprayings at about 15 days intervals were made during the period from June 17th to August 28th. The dates of spraying were June 17th, July 3rd, July 19th and August 6th. Samples for population counts were taken at the 1st, 4th, 7th, 11th and 15th days after the date of each treatment. For reasons that will be mentioned later, the third spraying was carried out with the insecticides alone.

Results of treatments were estimated by counting the red spider mites on representative samples of 10 full-grown cotton leaves taken from randomm plants in each plot, one from the bottom and one from the top of each plant.

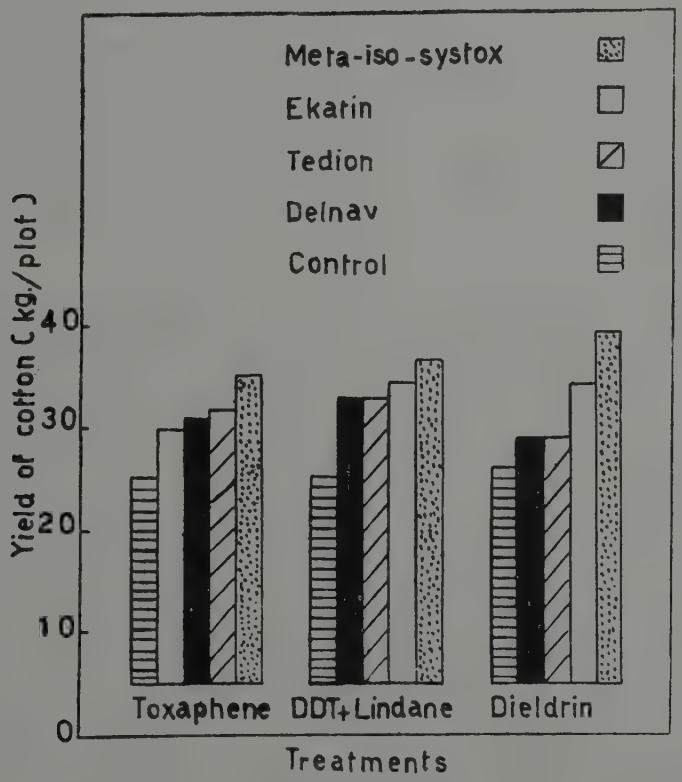

FIG. 1: The effect of treatment of cotton by combinations of certain acaricides and Toxaphene, Dieldrin and DDT+Lindane on the yield.

Each sample was kept in a tightly closed paper bag until counts were made as soon as possible in the laboratory. Direct counts of the mites were made under a wide-field binocular microscope. All living stages except eggs were counted. If some individuals were in the quiescent stage which precedes each moult, they were

first probed with a dissecting needle, and if they showed any signs of movement they were counted as alive (TOGASHI and PARKER, 1955, and MISTRIC, 1957). Counts were made on 10 square inches of the leaves area. One square inch was examined per leaf according to the method described by YOUNG and GAINES (1954) and the average number per square inch was considered as the infestation index.

Also comparisons were made on the basis of the yield of cotton.

IV. RESULTS

The spider mite population indices determined after each one of the four sprayings are recorded in Tables II to V. Each one of the records in these Tables is the average of the three replicates. The indices of the immature stages mentioned in the Tables do not include the eggs.

All the results have been subjected to an analysis of variance in order to examine the effects of the main factors, i.e., acaricides, dates of sampling, age of

TABLE II

Changes of red spider mites populations after the use of Tox phene, DDT+Lindane and Dieldrin alone and in combination with the acaricides Delnav, Ekatin, Meta-iso-systox and Tedion.

Insecticides and acaricides combinations	Infestation indices (average of 3 replicates)											
	Adults						Immature stages					
	Dates of sampling						Dates of sampling					
	18/6	21/6	24/6	28/6	2/7	Mean	18/6	21/6	24/6	28/6	2/7	Mean
Toxaphene	0.4	0.5	0.9	1.2	1.2	0.8	0.6	0.9	1.8	3.1	4.7	2.2
Toxaphene+Delnav .	0.1	0.1	0.2	0.6	0.6	0.3	0.4	0.4	0.6	0.8	2.5	0.9
Toxaphene+Ekatin ..	0.1	0.0	0.0	0.0	0.1	0.0	0.3	0.1	0.0	0.0	0.0	0.1
Tox.+Meta-iso-systox	0.0	0.0	0.1	0.3	0.3	0.1	0.6	0.4	0.3	0.4	1.7	0.7
Toxaphene+Tedion .	0.4	0.2	0.2	0.3	0.6	0.3	0.7	0.6	1.1	1.6	2.2	1.2
DDT+Lindane	0.3	1.0	1.7	2.3	2.6	1.6	0.8	1.7	2.8	4.1	10.1	3.9
DDT+Delnav	0.1	0.1	0.2	0.2	0.5	0.2	0.2	0.2	0.3	0.3	0.3	0.3
DDT+Ekatin	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.1	0.1
DDT+Meta-iso-systox	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
DDT+Tedion	0.2	0.3	0.3	0.5	0.1	0.3	0.5	0.4	0.5	0.7	1.9	0.8
Dieldrin	0.2	0.5	0.9	1.6	3.9	1.4	0.3	1.4	2.6	3.6	7.6	3.1
Dieldrin+Delnav	0.4	0.4	0.5	0.6	0.4	0.5	0.9	0.9	1.1	1.2	2.1	1.2
Dieldrin+Ekatin.....	0.0	0.0	0.1	0.2	0.0	0.1	0.2	0.1	0.0	0.0	0.0	0.1
Dieid.+Meta-iso-systox	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Dieldrin+Tedion	0.2	0.1	0.4	0.6	2.3	0.7	0.8	1.0	1.6	2.1	7.6	2.6

mites and their important interactions. Also the least significant differences (L.S.D.) at 95% level of probability of the above factors was calculated and used for comparisons between the different treatments. From the above statistical analysis of the results the following deductions could be presented:

(1) After the first spraying, all the acaricides gave significant effects in reducing the population of the immature stages and adults of the spider mites. This effect continued until the date of the second spraying. The two phosphorous compounds, Ekatin and Meta-iso-systox, at the dosages used, were the most effective materials among the tested acaricides on both adults and immature stages, whatever the insecticide combined with them. When comparing the phosphorous compound Delnav with the sulphur compound Tedion, their effect on the adults did not vary significantly, whereas the effect of Delnav on the immature stages was significantly higher than that of Tedion. When comparing the effect of the combinations of Delnav with each one of the three insecticides used, the best results on both adults and immature stages were obtained with its combination with DDT+Lindane followed by Toxaphene, then Dieldrin. The results of combinations of Tedion were nearly the same as those of Delnav.

TABLE III

Changes of red spider mites populations after the use of Toxaphene, DDT+Lindane and Dieldrin alone and in combination with the acaricides Delnav, Ekatin, Meta-iso-systox and Tedion.

Insecticides and acaricides combinations	Infestation indices (average of 3 replicates)											
	Adults						Immature stages					
	Dates of sampling						Dates of sampling					
	4/7	7/7	10/7	14/7	18/7	Mean	4/7	7/7	10/7	14/7	18/7	Mean
Toxaphene	3.1	4.4	6.1	5.0	4.1	4.5	7.0	10.3	15.9	25.4	34.8	18.7
Toxaphene+Delnav	0.7	1.3	2.2	2.3	2.4	1.8	3.1	3.5	4.4	6.0	7.6	4.9
Toxaphene+Ekatin	0.0	0.0	0.0	0.2	0.5	0.1	0.0	0.0	0.1	0.1	0.2	0.1
Tox.+Meta-iso-systox	0.0	0.0	0.1	0.1	0.3	0.1	0.1	0.1	0.1	0.3	0.4	0.2
Toxaphene+Tedion	1.2	1.1	1.1	0.9	0.8	1.0	3.5	3.7	4.5	5.5	6.9	4.8
DDT+Lindane	2.3	3.9	5.6	5.4	5.0	4.4	12.8	20.3	29.3	47.6	66.0	35.2
DDT+Delnav	0.0	1.0	1.6	1.8	2.0	1.3	0.3	1.3	2.7	2.7	2.7	1.9
DDT+Ekatin	0.0	0.0	0.0	0.4	0.8	0.2	0.1	0.0	0.0	0.0	0.1	0.0
DDT+Meta-iso-systox	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.2	0.1
DDT+Tedion	0.2	0.5	0.8	1.0	1.3	0.8	2.1	1.2	0.7	0.8	2.1	1.4
Dieldrin	2.5	3.4	4.8	4.5	4.1	3.9	17.3	20.0	22.4	40.3	58.7	31.7
Dieldrin+Delnav	0.2	0.6	1.1	1.6	2.3	1.2	1.6	1.3	1.3	4.1	7.1	3.1
Dieldrin+Ekatin	0.0	0.0	0.2	0.3	0.5	0.2	0.0	0.0	0.1	0.3	0.4	0.2
Diel.+Meta-iso-systox	0.0	0.1	0.3	0.7	1.2	0.5	0.0	0.0	0.1	0.8	1.8	0.5
Dieldrin+Tedion	1.3	1.4	1.7	1.9	2.1	1.7	4.2	5.2	7.3	8.5	10.1	7.1

(2) The results obtained after the second spraying were nearly the same as those of the first spraying. The effect of the four acaricides gave satisfactory control effects during the 15 days period until the date of the 3rd spraying, except in the case of Delnav combined with either Toxaphene or Dieldrin. The population of the adult mites in the plots treated with those two combinations started to increase nearly to the same level of the check plots at the count made on the 15th day after the date of spraying.

(3) The third spraying, as mentioned before, was carried out with the insecticides alone in order to find chance for comparing the duration of the residual effect of the acaricides. The effect of all the acaricides on the immature stages continued until nearly the date of the fourth spraying, i.e. about 30 days.

As regards the adult mites, the effect of Delnav combined with Toxaphene and Dieldrin became negligible before the date of the third spraying. The effect of Delnav combined with DDT+Lindane also expired soon after that date. The count made in the plots treated with that combination on the 4th day after the date of the third spraying showed nearly similar results as in the representative check plots. The residual effect of Ekatin continued to about 17 days when combined with

TABLE IV

Changes of red spider mites populations after the use of Toxaphene, DDT+Lindane and Dieldrin alone and in combination with the acaricides, Delnav, Ekatin, Meta-iso-systox and Tedion.

Insecticides and acaricides combinations	Infestation indices (average of 3 replicates)											
	Adults						Immature stages					
	Dates of sampling						Dates of sampling					
	20/7	23/7	26/7	30/7	5/8	Mean	20/7	23/7	26/7	30/7	5/8	Mean
Toxaphene	3.4	2.9	1.5	0.1	0.1	1.6	36.3	27.4	19.3	4.8	0.2	17.6
Toxaphene+Delnav .	2.8	3.2	1.7	0.4	0.2	1.7	8.9	9.7	5.6	2.5	0.3	5.4
Toxaphene+Ekatin ..	0.6	0.6	0.3	0.0	0.0	0.3	0.5	0.8	0.9	1.3	0.3	0.7
Tox.+Meta-iso-systox	0.3	0.4	0.2	0.0	0.0	0.2	0.3	0.2	0.4	0.4	0.6	0.4
Toxaphene+Tedion .	1.4	2.1	1.5	0.8	0.3	1.2	7.0	7.3	4.4	0.4	0.4	3.9
DDT+Lindane	3.9	2.9	1.5	0.4	0.0	1.7	54.0	42.0	25.3	11.0	0.0	26.4
DDT+Delnav	2.2	2.5	1.3	0.5	0.0	1.3	2.2	1.5	0.9	0.4	0.3	1.1
DDT+Ekatin	1.1	1.5	1.0	0.7	0.0	0.9	0.8	1.5	3.3	3.5	0.1	1.8
DDT+Meta-iso-systox	0.2	0.3	0.2	0.2	0.1	0.2	0.4	0.7	0.8	1.1	0.2	0.6
DDT+Tedion	2.3	3.5	1.6	0.7	0.0	1.6	2.8	3.7	2.6	1.8	1.0	2.4
Dieldrin	3.6	3.2	1.6	0.3	0.0	1.7	53.0	47.0	31.3	13.6	0.1	29.0
Dieldrin+Delnav	3.6	5.1	2.3	0.4	0.0	2.3	12.4	17.1	5.8	8.0	0.1	8.7
Dieldrin+Ekatin.....	2.8	2.2	1.2	0.5	0.1	1.3	2.5	4.8	3.8	3.1	0.8	3.0
Diel.+Meta-iso-systox	1.0	0.9	0.4	0.0	0.1	0.5	1.4	1.1	0.8	0.5	0.8	0.9
Dieldrin+Tedion	2.8	3.5	2.1	0.5	0.0	1.8	14.0	19.0	13.3	6.6	0.1	10.6

TABLE V

Changes of red spider mites populations after the use of Toxaphene, DDT+Lindane and Dieldrin alone and in combination with the acaricides, Delnav, Ekatin, Meta-iso-systox and Tedion.

Insecticides and acaricides combinations	Infestation indices (average of 3 replicates)											
	Adults						Immature stages					
	Dates of sampling						Dates of sampling					
	7/8	10/8	13/8	17/8	21/8	Mean	7/8	10/8	13/8	17/8	21/8	Mean
Toxaphene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Toxaphene+Delnav..	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.0	0.1
Toxaphene+Ekatin ..	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Tox.+Meta-iso-systox	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Toxaphene+Tedion .	0.2	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0
DDT+Lindane	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.1
DDT+Delnav	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DDT+Ekatin	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.0	0.0	0.0	0.1
DDT+Meta-iso-systox	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DDT+Tedion	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0 0	0.0	0.1
Dieldrin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dieldrin+Delnav	0.1	0.1	0.0	0.0	0.0	0.0	0.5	0.2	0.0	0.0	0.0	0.1
Dieldrin+Ekatin.....	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Diel.+Meta-iso-systox	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dieldrin+Tedion	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.1

Dieldrin and about 20 days when combined with either DDT+Lindane or Toxaphene. Meta-iso-systox showed continuous control throughout a period of 30 days when combined with any one of the three insecticides. Tedion combined with DDT+ Lindane and Dieldrin remained effective for about 17 days, but when combined with Toxaphene, its effect continued for about 20 days.

(4) After the fourth spraying, the spider mite population in all the plots was very low, and no appreciable differences between the different treatments were observed.

The effect of the combinations on the cotton yield is represented in Figure 1 which shows the average yield in kilograms of three replicates of each treatment. The statistical analysis of these yields revealed the following:

All plots treated with combinations of insecticides and acaricides gave significant increase in cotton yield as compared with those treated with insecticides alone. All the plots treated with Meta-iso-systox gave the best yield with no significant differences between its combinations with any one of the three insecticides. Ekatin came second to Meta-iso-systox. Comparing these two materials with each other,

Meta-iso-systox gave higher yield than did Ekatin when combined with Dieldrin and Toxaphene, and about the same yield as Ekatin when combined with DDT+ Lindane.

The two acaricides Delnav and Tedion gave comparable results in all their combinations. They both came in order after Meta-iso-systox and Ekatin.

V. CONCLUSIONS AND DISCUSSION

Field experiments were conducted during the season of 1958 for the control of the red spider mites on cotton with four different acaricides combined with three insecticides which have been commonly used in this country for the control of late season cotton pests. The four acaricides used were Tedion, Ekatin, Delnav and Meta-iso-systox. The insecticides used were, Toxaphene, Dieldrin and a mixture of DDT+Lindane.

Meta-iso-systox and Ekatin, at the dosages mentioned above, were the most effective materials in reducing all stages of the spider mites. Their effects continued for a longer period than those of the other two acaricides. The effect of the two phosphorous compounds was equal in all their combinations with the different insecticides. The population of spider mites in all plots treated with those two materials was significantly lower than all the other plots and the check plots throughout the whole period of the experiment.

The phosphorous compound Delnav at the rate used, also gave satisfactory results in controlling the red spider mites on cotton with some variations, specially on the adults, between the combinations with the three insecticides. The effectiveness of Delnav in comparison with other acaricides has also been proved by WILCOX and HOWLAND (1957) who conducted tests against *Tetranychus telarius* infesting lima beans in southern California from the year 1952 to 1955. MISTRIC (1957) also found that Delnav gave comparable results with Parathion and Aramite.

The sulphur compound, Tedion, gave results nearly similar to those of Delnav. The effect of this compound, specially on the adults, varies as in the case of Delnav according to its different combinations with the three insecticides. FERGUSON (1958) found that under field conditions the residual effectiveness of Tedion has ranged from 30 to over 100 days depending upon the crop and weather conditions. He mentioned also that the biological performance of Tedion in the laboratory has demonstrated a mode of action rather unique among pesticides. With specific reference to the control of *Tetranychus telarius* (L.), it has been demonstrated that adult female mites, although not themselves quickly killed when in direct contact with Tedion, deposited eggs either that did not hatch or were delayed in their normal hatching period.

The yield of the different plots of any given insecticide varied. All other factors being the same, this variation in yield might be due to the mites infestation factor

which varied according to the acaricide used. It is known that the spider mites are capable of causing serious reduction in the yield, specially when conditions are favourable for their rapid increase in population. This reduction in yield might amount up to 30-77% or more (ROUSSELL, 1953-1954). According to the results of the present work, the reduction caused by the spider mites in the plots not treated with acaricides varied between 20-33%. On the other hand, the yield of the plots treated with acaricides was in general significantly higher than the untreated plots. The best yield was obtained from the plots treated with Meta-iso-systox in all its combinations. Plots treated with Ekatin, specially when combined with DDT+ Lindane and Dieldrin, was second to those treated with Meta-iso-systox.

Whether this variation in yield is due to any insecticidal effects of the acaricides used on the boll-worms will be classified in a future communication.

VI. SUMMARY

Field experiments were conducted for the control of the red spider mites infesting cotton by the use of Meta-iso-systox, Ekatin, Delnav and Tedion combined with the insecticides Toxaphene, DDT+Lindane and Dieldrin, which have been commonly used for controlling the late season cotton insect pests.

All the tested acaricides at the rates used gave variable satisfactory control results against the adults and immature stages of the mites. There were also some variations between the different combinations of each acaricide with the different insecticides.

The two phosphorous compounds, Meta-iso-systox and Ekatin, at the dosages used, were the most effective materials whatever the insecticide combined with them.

The residual effect of the four acaricides on the adults and immature stages varied. The effect on the immature stages continued for about 30 days after application. As regards the adults, the effect of Delnav continued for about 15-17 days, Ekatin and Tedion 17-20 days and Meta-iso-systox 30 days.

All the plots treated with the acaricidal combinations gave significant increase in cotton yield. The plots treated with Meta-iso-systox gave the best yield. The reduction in the yield of the plots not treated with acaricides varied between 20-33%.

VII. ACKNOWLEDGMENT

This investigation forms a part of the program of work in the Department of Plant Protection, Faculty of Agriculture, Cairo University. The authors are indebted to Messrs. THABET Brothers, PHILIPS and HERCULES POWDER COMPANY, for supplying the acaricides used in this work.

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A NEW PLANOCOCCINE MEALYBUG ON *STATICE* FROM EGYPT

[*Homoptera*: *Coccoidea-Pseudococcidae*]

(with 1 Text-Figure)

by Y.M. EZZAT, PH. D,

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The production of Professor G. DE LOTTO on the Pseudococcidae of Africa south of the Sahara is undoubtedly a useful contribution. An appreciation to his work is here expressed in terms of a new mealybug based on his surname.

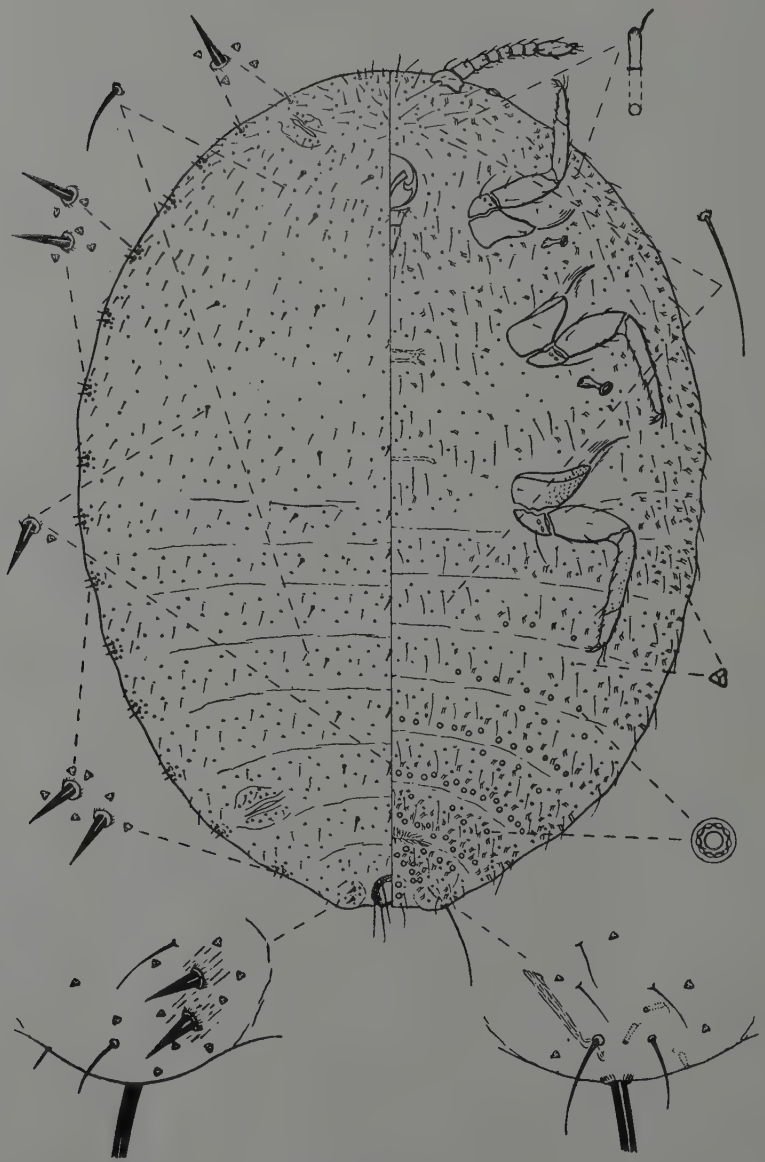
It has been possible to recognise and delineate this species through the facilities offered by the Ministry of Agriculture, Egypt; and the Department of Plant Protection, College of Agriculture, Ein Shams University. To these institutes, the author is greatly indebted.

Crisicoccus delottoi, sp. n.

ADULT FEMALE: Body broadly oval, about 1.7 mm. long and 1.3 mm. wide. With 17 pairs of cerarii, preocular pair absent, ocular and anterior prothoracic cerarii with one cerarian seta only, other cerarii including those of the anal lobes are with two cerarian setae, all conical and about 20 microns long; anal lobe cerarii with about 10 associated trilocular disc pores, and 3 auxiliary setae, 8-24 microns long, other cerarii with about 3-7 associated trilocular disc pores and no auxiliary setae; dorsal surface of the anal lobe, in well stained mounts, appear slightly sclerotized around the bases of cerarian setae.

Head: Antennae 8-jointed; average measurements, in microns, as follows: I, 36; II, 36; III, 33; IV, 21; V, 27; VI, 30; VII, 30; VIII, 75. Eye bases about 10 microns high and 25 microns in diameter. Beak conical, about 90 microns long and 60 microns wide at base.

Thorax: Legs normal; measurements of posterior leg, in microns, about as follows: trochanter 78 × 42; femur, 168×66; tibia, 180 × 36., tarsus, 96 × 30;



Crisicoccus delottoi, sp. n., × 70

claw, 30; tarsal digitules, 42: claw digitules, 18; translucent dots present on posterior coxae, few on posterior tibiae. Spiracular apodemes measure, in microns, about as follows: anterior, 48 long, 24 wide at atrium; posterior, 60 long, 30 wide at atrium; median portion in all is less than half as wide as atrium.

Abdomen: Anal ring normal, about 85 microns in diameter, with 6 setae, each about 100 microns long. Cisanal and obanal setae shorter than anal ring setae, cisanal about 65 microns, obanal 35 microns. Anal lobe bar moderately sclerotized, not extending to base of apical seta, bar seta about 40 microns long, apical setae longer than anal ring setae, about 170 microns long. Circulus absent.

Dermal structures: Ostioles slightly sclerotized, with about 5 or 6 trilocular disc pores and 1 or 2 setae on every lip; anterior pair rather reduced.

Dorsal body setae short and stout, median and submedian setae on abdominal segments II to VIII and some on every thoracic segment are similar to cerarian setae, a trilocular disc pore is usually found near any of these large setae. Ventral body setae longer and flagellate.

Trilocular disc pores sparsely distributed over both surfaces in the usual pattern, spaced about 3-15 times their diameter on dorsum, more widely spaced on venter.

Dorsal tubular ducts absent. Ventral tubular ducts of the oral collar type only, about 7 × 3 microns, numerous on marginal areas and getting fewer mesially. Numbers about as follows: abdominal segments X and IX, 30; VIII, 64; VII, 52; VI, 36; V, 34; IV, 36; III, 44; II, 22; metathorax, 50; mesothorax, 74; prothorax, 50; head, 20.

Multilocular disc pores on ventral surface only, present on abdominal segments IV to X, usually in simple rows not reaching the lateral margins, few on anterior parts of segments VI to IX, apparently absent elsewhere. Approximate numbers as follows: abdominal segments X, 3; IX, 20; VIII, 31; VII, 40; VI, 27; V, 11; IV, 6.

Described from 8 mounted adult females, three of which are poor and mounted together in one slide, the rest are mounted individually. All collected on *Statice* sp., 40 kilometres south of Zukari, Egypt. Holotype and paratypes. The holotype is deposited in the United States National Collection while the paratypes are kept in the Coccid Collection, Ministry of Agriculture, Egypt.

This species is similar to *Crisicoccus dischidae* (Takahashi) in having 17 pairs of cerarii and each with not more than 2 cerarian setae. It differs mainly by having stout conical cerarian setae and by having some dorsal setae similar to those of the cerarii.

NOTE: It may be of importance to state that this species is the first representative to be known of the genus *Crisicoccus* Ferris in Egypt. Meanwhile, other representatives of this genus are known in the area from India to west of the United States passing by Japan. In that area they attack certain plants of economic importance such as *Pyrus communis* (pear), *Pinus* trees, and orchids.

SUMMARY

This paper is mainly the description of a new species, and also represents the first record from Egypt for the genus *Crisicoccus* Ferris. The name of this new mealybug is based on the surname of Professor G. De Lotto in appreciation to his efforts in dealing with the Pseudococcidae of Africa south of the Sahara.

REFERENCE

Ezzat, Y. M., and McConnell, H. S. (1956): A classification of the mealybug tribe *Planococcini* (Pseudococcidae, Homoptera) (University of Maryland, Agriculture Experiment Station, Bull. A-84, pp. 22-31.)

TRIONYMUS WILLIAMSI, A NEW SPECIES OF GRASS-INFESTING MEALYBUG FROM THE SUBURBS OF CAIRO, EGYPT

[*Homoptera*: *Coccoidea-Pseudococcidae*]

(with 1 Text-Figure)

by Y. M. EZZAT, PH. D.,

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Dr. D. J. WILLIAMS, of the Commonwealth Institute of Entomology, is nowadays taking a great part in the study of African mealybugs. He has already achieved considerable results and still looking for more. In recognition of Dr. WILLIAMS' work, it is here wished to dedicate the following new mealybug in his honour.

The late Professor FERRIS deserves the credit of illustrating this species. The Department of Plant Protection, College of Agriculture, Ein Shams University; and the Ministry of Agriculture, Egypt, offered the requirements needed the work.

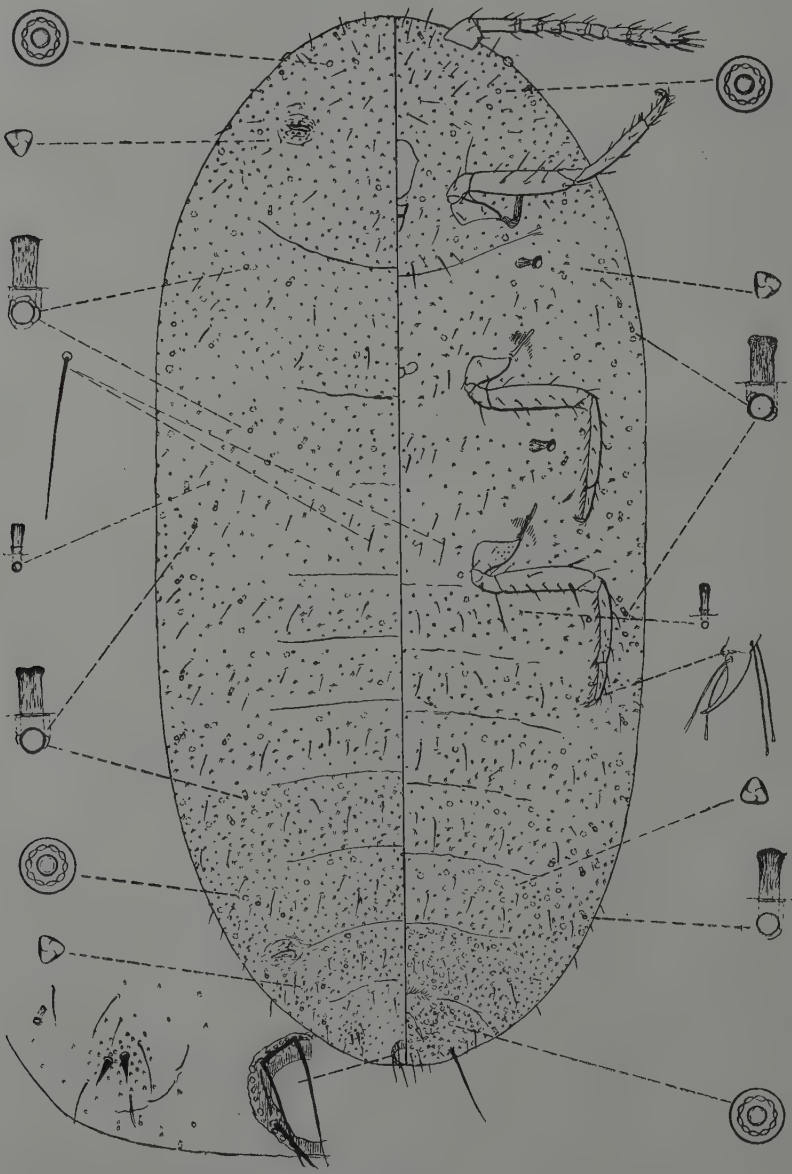
Trionymus williamsi, sp. n.

ADULT FEMALE: Body oval, elongate, about 2.7 (1.8 - 3.6) mm. long and 1.1 (0.7-1.4) mm. wide.

With the anal lobe pair of cerarii only. Each cerarius of this pair has two conical setae, about 20 microns long, associated with a crowd of about 27 trilocular disc pores and 4 setae ranging from 30 to 45 microns long.

Head: Antennae 8-jointed; measurements, in microns, about as follows: I, 48; II, 54; III, 30; IV, 30; V, 42; VI, 24; VII, 36; VIII, 90; Eye bases about 12 microns high and 24 microns in diameter. Beak small, about 84 microns long and the same wide at base.

Thorax: Legs normal; measurements of posterior leg, in microns, about as follows: trochanter, 72 × 36; femur, 198 × 24; tarsus, 90 × 21; claw, 24; tarsal



Trionymus williamsi, sp. n., × 60.

digitules, 54; claw digitules, 24; translucent dots on posterior coxae and very few on the distal part of posterior tibiae. Spiracular apodemes measuring in microns about as follows: anterior, 42 long, 24 wide at atrium; posterior, 48 long, 30 wide at atrium; median portion about half as wide as atrium.

Abdomen: Anal ring normal, on dorsal surface close to apex of abdomen, about 76 microns in diameter; anal ring setae about 96 microns long. Cisanal setae about 66 microns and obanal setae about 46 microns long. Apical setae longer than anal ring setae, about 140 microns. Circulus absent.

Dermal structures: Ostioles prominent due to elevation rather than to sclerotization, with about 5-7 trilocular disc pores on every lip; posterior lip of thoracic pair and anterior lip of abdominal pair with 1-3 setae each, other lips are without any seta.

Dorsal and ventral body setae similar, long and flagellate.

Trilocular disc pores sparsely distributed over both surfaces in the usual pattern, spaced about 4-7 times their diameter on dorsum, more widely spaced on venter.

Tubular ducts of the oral collar type only. However, some of these ducts are comparatively large and having one or more adventitious oral cells adjoining the main orifice of the duct. On the dorsal surface the length of these ducts is about 8 microns and the diameter of the main orifice is about 6 microns; they are arranged in small groups of about 1 to 3 ducts on each of the marginal areas of every body segment; other smaller ducts on dorsum are about 5 microns long and 2 microns in diameter of orifice, these are more numerous, roughly arranged on abdomen in transverse segmental wide rows while without any obvious arrangement on thorax, apparently absent on head, approximate numbers are about as follows: abdominal segments VIII, 54; VII, 42; VI, 68; V, 38; IV, 29; III, 20; II, 18; metathorax, 20; mesothorax, 18; prothorax, 22; On ventral surface one of the ducts with the adventitious oral cells is usually present close to each margin of every body segment; the smaller ducts are much more numerous, arranged on abdominal segments in transverse rows, on all marginal areas of thorax and around middle and posterior coxae, absent on head, numbers are about as follows: abdominal segments IX, 36; VIII, 50; VII, 64; VI, 58; V, 50; IV, 24; III, 16; II, 12; metathorax, 12; mesothorax, 24; prothorax, 6.

Multilocular disc pores present on both dorsal and ventral surfaces. On dorsum, they are few in number, arranged in simple transverse segmental rows; approximate numbers as follows: abdominal segments VIII, 7; VII, 12; VI, 18; V, 7; IV, 5; III, 6; II, 5; metathorax, 10; mesothorax, 11; prothorax, 7; head, 1. On venter, multilocular disc pores are more numerous, arranged in transverse rows 1-3 pores wide on most of abdominal segments, near anterior and posterior margins of segments VIII and IX and near anterior margins only of other segments; on thorax, they are present on marginal areas and around coxae; absent on head;

approximate numbers as follows: abdominal segments X, 14; IX, 29; VIII, 65; VII, 34; VI, 20; V, 16; IV, 7; III, 5; II, 2; metathorax, 11; mesothorax, 13; prothorax, 19.

Described from the following mounted adult females: 3 specimens on *Imperata cylindrica*, Maadi, Egypt, December 25, 1932, holotype and paratypes; 1 specimen on "grasses", Barrage, Egypt, October 1931. The holotype is placed in in the United States National Collection and the paratypes are in the Coccid Collection, Ministry of Agriculture, Egypt.

This species could be easily distinguished from any other species in the genus *Trionymus* by having that type of ducts with the additional oral cells adjoining the main orifice.

Though the tubular ducts with the additional oral cells are common in the genus *Anisococcus* Ferris, it is here preferred to place this species in *Trionymus* Berg until further study of the grass infesting mealybugs from different parts of the world is carried on. Apart of these characteristic ducts, the species under consideration is fitting nicely in *Trionymus*. Moreover, it shows certain important differences to the genus *Anisococcus*, such as: the anal lobe cerarii are with two conical setae only and no sclerotization of any kind, the additional oral cells adjoining the main orifice of the tubular ducts may be more than one cell, and the multilocular disc pores are present even on dorsum.

SUMMARY

This paper describes a new mealybug from the family *Pseudococcidae*. The new species is dedicated in the honour of Dr. D. J. Williams for his efforts in the study of African mealybugs.

LITERATURE

Ferris, G. F. (1950 and 1953): The *Pseudococcidae* (Parts 1 and 2) (Atlas of the scale insects of North America, V and VI).

A NEW SPECIES OF *HUMOCOCCUS* FERRIS FROM ALEXANDRIA, EGYPT

[*Homoptera*: *Coccoidea-Pseudococcidae*]

(with 1 Text-Figure)

by Y. M. EZZAT, PH. D.,

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Howard L. MCKENZIE of the University of California is one of the most efficient coccidologists in the present time. His efforts in coccid taxonomy are definitely of great help towards better knowledge of scale insects. The late Professor FERRIS did well by choosing MCKENZIE to replace him. Therefore, a new species is here named after MCKENZIE as a sign of best wishes for him in his recent position with the University of California.

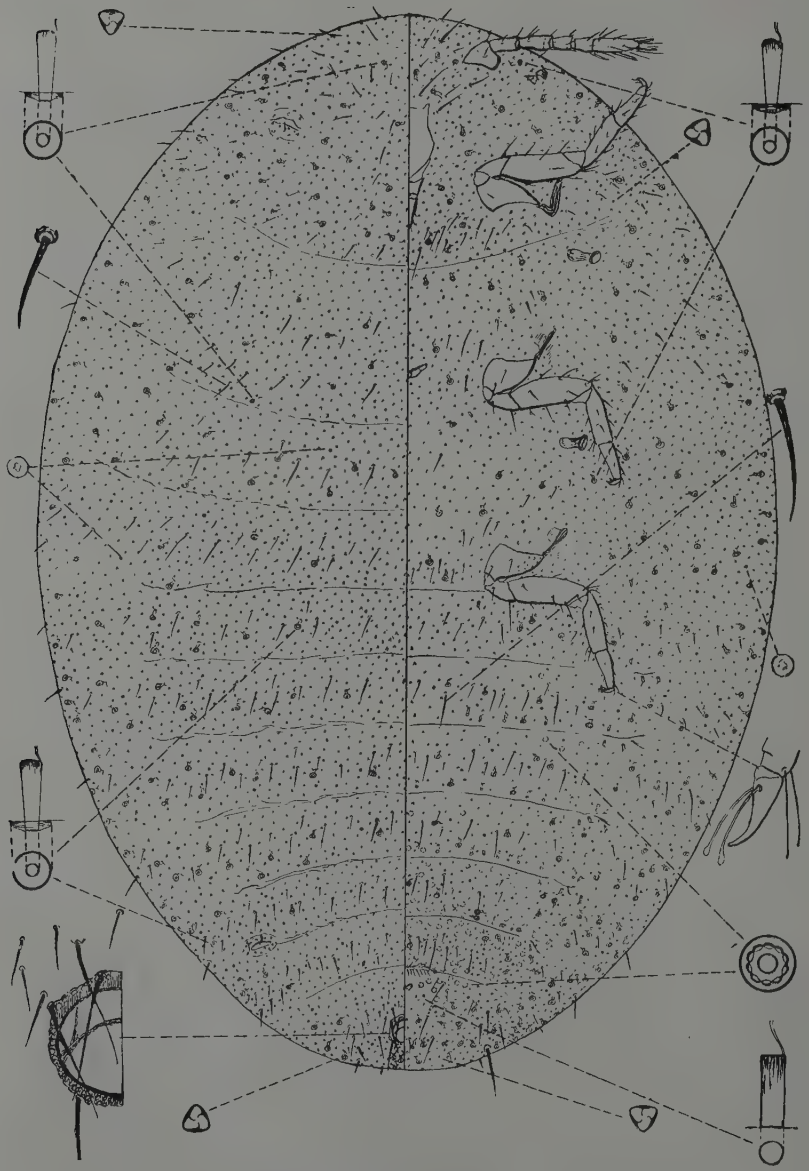
Professor FERRIS' help, in recognising the generic status of this new species and in drawing its main features, is here to be registered with the deepest sense of appreciation. Gratitude is also due to the Ministry of Agriculture, Egypt; and to the Department of Plant Protection, College of Agriculture, Ein Shams University; for offering the material and facilities necessary for the study.

Humococcus mackenziei, sp. n.

ADULT FEMALE: Body broad oval, about 1.8 mm. long and 0.9 mm. wide. Cerarii practically wanting except for two stout though long setae in the place of each anal lobe cerarius. These setae are about 36 microns long and are not associated with any particular crowding of trilocular disc pores.

Head: Antennae 6-jointed; measurements, in microns, about as follows: I, 36; II, 42; III, 42; IV, 24; V, 30; VI, 60. Eye bases small, about 9 microns high and 18 microns in diameter. Beak large, about 126 microns long and 90 microns wide at base.

Thorax: Legs stout; measurements of posterior leg, in microns, about as follows: trochanter, 78×36; femur, 114×54; tibia, 102×30; tarsus, 78×24; claw,



Humococcus mackenziei, sp. n., × 90.

tarsal digitules, and claw digitules are all equal in length, about 30 microns long; translucent dots present on posterior coxae only. Anterior spiracular apodemes about 54 microns long and 30 microns wide at atrium, the median portion is more than half as wide as atrium; posterior apodemes are about as large as anterior apodemes except for being slightly wider at atrium.

Abdomen: Anal ring simplified by lacking the inner band of pores, dorsal in position, normally separated from the posterior apex of body by its diameter or more, measuring about 65 microns in diameter. Anal ring setae short, as long as the diameter of the anal ring or slightly longer. Cisanal and obanal setae variable, as long as or longer than the anal ring setae, may reach the length of 150 microns, but always stouter than the anal ring setae. Circulus absent.

Dermal structures: Ostioles not prominent; thoracic pair with about 4 trilocular disc pores but no seta on anterior lip, 10 pores and an occasional seta on posterior lip; abdominal pair with about 10 pores and 2 setae on anterior lip, 10 pores but no seta on posterior lip.

Dorsal body setae stout at base, slightly flagellate at apical third, blunt at tip. Ventral body setae similar to dorsal setae except for being slightly longer.

Trilocular disc pores numerous, densely distributed over both surfaces in the usual pattern without any particular crowding, spaced about 2-4 times their diameter.

Tubular ducts on dorsum are all of the oral rim type with a narrow opening and a heavily sclerotized rim, about 10 microns long, diameter about 2 microns at opening, 8 microns at rim, and wider at interior base; arranged on most of the abdomen in transverse segmental rows, about 1-2 ducts wide and becoming wider towards the margins; these ducts are scattered over both thorax and head without any obvious arrangement; approximate numbers as follows: abdominal segments IX, 14; VIII, 9; VII, 10; VI, 25; V, 26; IV, 26; III, 19; II, 14; metathorax, 29; mesothorax, 34; prothorax, 44; head, 7. Ventral tubular ducts of two types; the oral rim type is nearly similar in size, shape, and arrangement to those of dorsum; approximate numbers as follows: abdominal segments X and IX, 44; VIII, 27; VII, 40; VI, 30; V, 29; IV, 27; III, 22; II, 18; metathorax, 36; mesothorax, 40; prothorax, 36; head, 10. The other type of ducts on venter is oral collar, less numerous, about 10 microns long and 4 microns wide, arranged on most of abdomen in simple transverse rows close to the posterior margins of the segments with few close to anterior margins, apprently absent on head and thorax; approximate numbers as follows: abdominal segments IX, 5; VIII, 9; VII, 11; VI, 25; V, 17; IV, 13; III, 6; II, 4.

Multilocular disc pores on ventral surface only, present mainly around vulva and on segment VII, few on segments IV to VI, never on marginal areas of segments, absent on abdominal segments II, III and X, also absent on thorax and head; approximate numbers as follows: abdominal segments IX, 19; VIII, 53; VII, 39; VI, 13; V, 7; IV, 2.

Simple disc pores of circular shape, about as wide as trilocular disc pores, are sparsely scattered over both dorsum and venter.

Described from the following mounted adult females, collected from El-Max, Alexandria, Egypt: 5 specimens on roots of *Zygophyllum album*, May 12, 1932, holotype and paratypes; 5 specimens on *Salicornia fruticosa*, March 10, 1932, paratypes. The holotype and one of the paratypes are deposited in the United States National Collection. All other paratypes are in the Coccid Collection, Ministry of Agriculture, Egypt.

This species is closer to *porterae* (Cockerell) than to any other species of *Humococcus* because of having so many oral rim tubular ducts on both dorsum and venter. However, it differs from *porterae* by having the anal ring with the outer band of pores present and with six setae only, the tubular ducts having a narrow opening and a rim which is much more in diameter than a trilocular disc pore, and by having more multilocular disc pores.

NOTE 1: Considering that in this species the anal ring is not quite simple, its inclusion in the genus *Humococcus* Ferris requires a slight extension of this genus. Therefore, in regard to the anal ring condition, the definition of *Humococcus* should be modified as follows: Anal ring more or less simplified, consisting merely of a narrow sclerotized ring or there may be few pores in the outer band, sometimes the outer band of pores is complete, but never with an inner band of pores.

NOTE 2: While the genus *Humococcus* Ferris is well represented in southwestern United States only, the species at hand represents the first record of this genus in Egypt.

SUMMARY

This paper represents a description of a new mealybug. It also represents the first record of the genus *Humococcus* Ferris, after having been slightly modified, in Egypt. The new species is named after Professor H.L. MCKENZIE of the University of California, Davis, as a sign of consideration to his efforts towards better knowledge of scale insects.

REFERENCE

FERRIS, G.F. (1953): The *Pseudococcidae* (Pt. 2) (Atlas of the scale insects of North America, VI, pp. 370-378).

ZUR SYSTEMATIK DER GATTUNG *ACROSTERNUM* FIEBER

[*Hemiptera-Heteroptera : Pentatomidae*]

(mit 14 Abbildungen)

von EDUARD WAGNER, Hamburg.

Die Gattung *Acrosternum* wurde von FIEBER (1861) als monotypisch aufgestellt. Als einzige Art beschreibt FIEBER *A. heegeri*, die damit zum Genotypus wird. MULSANT und REY (1866) vereinigten *Acrosternum* mit der Gattung *Nezara* Am. et Serv. Diese Vereinigung blieb bestehen, bis man später *Acrosternum* wieder zur selbständigen Gattung machte, so z. B. KIRITSCHENKO (1926).

Die paläarktischen Arten der Gattung *Acrosternum* Fieb. lassen sich nach dem Bau der Stirnschwiele in 2 Gruppen einteilen. Bei der einen Gruppe wird die Stirnschwiele vorn von den Wangen eingeschlossen. Zu dieser Gruppe gehören die Arten *A. breviceps* Jak., *A. sahlbergi* Reut., *A. satunini* Jak. und *A. bactriana* Kir. Nach KRITSCHENKO (1926) sind jedoch diese 4 Arten identisch und müssen den Namen *A. breviceps* Jak. führen. Bei *A. satunini* Jak. ist sich KIRITSCHENKO seiner Sache nicht sicher und bezeichnet diese Form "vorläufig" als var. *satunini* Jak. (*sahlbergi* Reut.) von *A. breviceps* Jak.

Die zweite Gruppe umfasst die Arten mit frei durchlaufender Stirnschwiele. Hierher gehören die Arten *A. heegeri* Fieb., *A. millierei* Mls., *A. canariensis* Lindbg. und *A. insularum* Lindbg., sowie die weiter unten beschriebene *A. arabicum*. Die Trennung der Arten dieser Gruppe ist recht schwierig und erweist sich ohne Untersuchung der Genitalien des Männchen stets als unsicher. Der Erste, der versuchte, hier Klarheit zu schaffen, war HORVATH (1888). Er trennt die Arten *A. heegeri* Fieb. und *A. millierei* Mls. durch eine Reihe von Merkmalen. Von diesen erweist sich die Form des Kopfes (Fig. 1-5) auch heute noch als geeignet. Das Arbeiten mit diesem Merkmal ist jedoch recht schwierig, weil die Unterschiede nur gering sind, besonders aber dadurch, dass sich die Zahl der Arten inzwischen auf 5 erhöht hat und nicht alle dieser Arten sich so klar unterscheiden wie *millierei* und *heegeri*.

Als 2. Merkmal führt HORVATH die Länge des Rostrum an. Auch dies Merkmal ist brauchbar. Mit seiner Hilfe lassen sich *heegeri* und *millierei* ebenfalls gut trennen, während die übrigen 3 Arten jeweils mit einer dieser Arten übereinstimmen.

Das Längenverhältnis zwischen dem 2. und dem 3. Fühlerglied dagegen eignet sich nicht zur Trennung der Arten. Eine genaue Messung bei zahlreichen Stücken ergab zwar eine geringe Schwankung, aber keine Unterschiede zwischen den Arten. Im Allgemeinen ist das 2. Glied etwas länger als das 3.

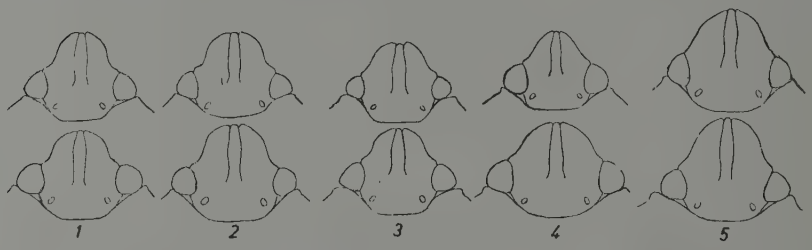


FIG. 1-5: Kopf von oben (7.5×)

1=*A. arabicum* nov. spec., 2=*A. millierei* Mls., 3=*A. insularum* Ldbg., 4=*A. rubescens* Noualh., 5=*A. heegeri* Fieb. — Oben=Männchen, unten=Weibchen.

Auch die von manchen Autoren angewandte Färbung der Fühler eignet sich nicht zur Trennung der Arten. Es konnten bei allen Arten mit Ausnahme von *A. sahlbergi* Reut. Tiere festgestellt werden, bei denen die Spitzenhälfte des 3. Gliedes sowie das 4. und 5. Glied ganz rot gefärbt waren, neben solchen, bei denen die Fühler einfarbig grün waren. Vermutlich handelt es sich bei den Tieren mit den zur Hälfte rot gefärbten Fühlern um frisch entwickelte Imagines, während diejenigen mit den einfarbig grünen Fühlern ältere (überwinterte) Stücke sind. Diese Rotfärbuug (Jugendrot) kann sich auch über die ganze Oberfläche des Tieres ausbreiten.

Ein wirklich brauchbares Merkmal zur Trennung der Arten ist die Form des Männchen-Genitalsegments. Auf dies Merkmal weist als Erster REUTER (1900) hin. Er zeigt dabei gleichfalls nur die Unterschiede zwischen *A. heegeri* und *A. millierei*. Die Unterschiede liegen hier vor allem in der Form der beiden Hinterecken und der zwischen ihnen liegenden Einbuchtung des Hinterrandes, und zwar ist es vor allem der untere Rand der Genitalöffnung, der starke Unterschiede aufweist. Jedoch auch der in der Genitalöffnung sitzende Analkonus ist für die Trennung der Arten brauchbar. Er trägt distal ein Paar Anhänge, deren Form für jede Art charakteristisch ist. Die Hinterecken des Genitalsegments sind bei *A. arabicum* n. sp. (Fig. 6) schlank und leicht gerundet, der untere Hinterrand ist kaum eingebuchtet. Bei *A. millierei* Mls. (Fig. 7) sind die Hinterecken breit, gerade abgestutzt, der untere Hinterrand ist stark eingebuchtet und die Einbuchtung fast rechteckig. Beie *A.*

insularum Linbg. (Fig. 8) sind die Hinterecken schlank und spitz, neben ihnen sitzt ein gerundeter Lappen, so dass die Ecke zweiteilig erscheint. Der untere Hinterrand ist tief eingebuchtet. *A. rubescens* Noualh. (Fig. 9) hat breite, spitzbogige Hinterecken, die Einbuchtung ist flach und der untere Hinterrand gewellt. *A. heegeri* Fieb. (Fig. 10) hat sehr breite, abgerundete Hinterecken. Die Einbuchtung ist fast rechteckig.

FIG. 6-10: Genitalsegment des Männchen von oben (15×)
6=*A. arabicum* nov. spec., 7=*A. millierei* Muls., 8=*A. insularum* Ldbg., 9=*A. rubescens* Noualh., 10=*A. heegeri* Fieb.

Die Parameren der *Acrosternum*-Arten sind sehr schwach chitinisiert und schwanken recht stark in der Form, so dass sie kaum geeignete Merkmale aufweisen. Der Penis dagegen trägt distal ebenfalls 2 Anhänge, die denen des Analkonus ähneln, eine konstante Form haben und sich daher für die Unterscheidung der Arten eignen.

Die Genitalsegmente der Weibchen (Fig. 11-14) unterscheiden sich gleichfalls; doch ist es nicht leicht, mit diesem Merkmal zu arbeiten. Unter den von aussen sichtbaren Teilen, sind es vor allem die Lappen der Segmente 7 und 8 sowie die 1. Gonapophysen, die sich durch ihre Form unterscheiden. *A. arabicum* n. sp. (Fig. 11)

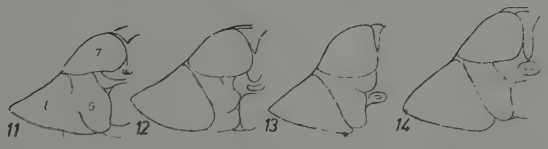


FIG. 11-14: Genitalsegment des Weibchen von hinten (15×)
11=*A. arabicum* nov. spec., 12=*A. millierei* Muls., 13=*A. insularum* Ldbg., 14=*A. heegeri* Fieb. — (7=Lappen das 7. Segments, 8=Lappen des 8. Segments, G=Gonapophysen).

weicht durch die niedrigen, spitzen Lappen des 7. Segments und die breiten Gonapophysen von den übrigen ab. *A. millierei* Mls. (Fig. 12) hat sehr kleine Gonapophysen und grosse, gerundete Lappen des 8. Segments. Bei *A. insularum* Ldbg. (Fig. 13) sind die Gonapophysen lang und schmal, die Lappen des 8. Segments spitz. Bei *A. heegeri* Fieb. (Fig. 14) sind die Segmente sehr gross, die Lappen des 7. und 8. Segments hoch und gerundet und die Gonapophysen lang.

Acrosternum arabicum, nov. spec.

Hell grün, einige Exemplare zeigen eine teilweise Rotfärbung, 1 Männchen und 1 Weibchen sind strohgelb. Ober- und Unterseite mit feinen, eingestochenen

Punkten, die in der Regel etwas dunkler gefärbt sind. Bei einigen Stücken sind auch die Ränder des Pronotum und der vordere Teil des Coriumaussenrandes gelblich. Glänzend, kahl. Gestalt verhaltnismässig lang und schmal, das Männchen 1.9 ×, das Weibchen 1.7-1.8 × so lang wie das Pronotum hinten breit ist.

Kopf (Fig. 1) kurz und breit. Stirnschwiele frei durchlaufend. Wangen vorn fast spitz, ihr Seitenrand vor den Augen stark eingebuchtet. Auge gross, Scheitel 2.5-2.7 × so breit wie das Auge. Fühler grün, die Spitzenhälfte des Fühlers bisweilen rot. Fühlerglieder schlank, das 1. Glied ist das kürzeste, Glied 2 etwa 2 × so lang wie das 1. und 1.0-1.1 × so lang wie das 3.; 4. Glied 1.3-1.4 × so lang wie das 3. und so lang oder etwas länger als das 5.

Pronotum sehr kurz und breit. Membran glashell, durchsichtig. Connexivum weissgelb, äussere Hinterecke der Segmente ohne schwarzen Punkt. Abdomen ohne Kiel. Beine grün — bei gelben Exemplaren gelb — mit sehr feinen hellen Haaren. Das Rostrum hat eine schwarze Spitze und reicht bis zur Spitze der Hinterhüften.

Genitalsegment des Männchen (Fig. 6) breiter als lang, Seiten fast gerade, nach hinten stark divergierend. Hinterecken schlank, aber abgerundet, unterer Hinterrand seicht aber gleichmässig eingebuchtet. Analkonus mit 2 grossen, runden, divergierenden Lappen. Parameren etwa rechtwinklig gebogen, kurz und sehr breit, distal stumpf. Penis verhältnismässig gross, distal mit 2 zweiteiligen Anhängen.

Genitalsegmente des Weibchen (Fig. 11) breit und flach, Lappen des 7. Segments flach, aussen spitz, Lappen des 8. Segments etwa dreieckig, aussen ebenfalls spitz. Gonapophysen lang und breit.

Lange: Männchen 10-11mm, Weibchen 10-11.7 mm.

A. arabicum n. sp. stimmt in der Länge des Rostrum mit *A. millierei* Mls. überien, in der Form des Kopfes ähnelt sie ebenfalls dieser Art, doch ist der Teil des Kopfes vor den Augen noch kleiner, die Augen sind grösser und der Scheitel ist schmaler. In der Form des Männchen-Genitalsegments unterscheidet sich die Art von allen übrigen durch die schlanken Hinterecken und die sehr flache Einbuchtung des unteren Hinterrandes. Die Weibchen-Genitalsegmente haben sehr spitze Aussenecken der Segmente und spitflachere Lappen.

Ich untersuchte 11 Männchen und 14 Weibchen aus Saudi-Arabien: El Riyadh April 1958 1 Männchen, 4 Weibchen und Juni 1958 10 Männchen, 10 Weibchen (E. Diehl leg.). Das Material wurde mir in liebenswürdiger Weise von Herrn Dr. H. Eckerlein, Coburg zur Verfügung gestellt.

Acrosternum canariense Lindberg

In seiner Beschreibung dieser Art (1953) stellt Lindberg fest, dass die von Noualhier (1893) beschriebenen Abarten *rosea* und *rubescens* identisch mit *A. canariense* sind. Er hat auch die im Museum National d'Histoire Naturelle in Paris befindlichen Typen dieser beiden Varianten untersucht. Da sich beide Namen also ohne Zweifel auf *A. canariense* beziehen und gültig sind, haben sie auch Priorität

vor dem Namen *canariense*. Die Art muss also einen von ihnen tragen. Da beide Namen gleichzeitig publiziert wurden und auch auf der gleichen Seite der Arbeit NOUALHIERS stehen, muss der voranstehende Name *rubescens* eintreten und die Art demzufolge *Acrosternum rubescens* Noualhier 1893 heissen. Der Name *rosea* Noualh. wird damit zum strikten Synonym dazu.

Damit verschwinden diese beiden Namen (*rubescens* und *rosea*) aber auch bei *A. heegeri* Fieb. und *millierei* Mls., für deren rotgefärbte Exemplare sie bisher angewandt wurden. Wie bereits oben erwähnt wurde, sind solche rotgefärbten Tiere aber keine echten Färbungsvarianten, sondern nur Stadien eines Ausfärbungsprozesses, dessen Endglied das einfarbig grüne Tier ist. Es wäre daher falsch, einem solchen Stadium bei diesen beiden Arten jetzt einen neuen Namen zu geben.

Auch bei *A. rubescens* sollte nunmehr kein Unterschied mehr gemacht werden zwischen einer grünene Stammform und einer roten Variante.

TABELLE DER PALÄARKTISCHEN ARTEN VON *Acrosternum* FIEB.

1 (10) Stirnschwiele frei druchlaufend, vorn nicht von den Wangen eingeschlossen.

2 (5) Rostrum die Mitte des 2. Bauchsegments erreichend oder überragend. Rand des Kopfes vor den Augen nur schwach eingebuchtet (Fig. 4+5).

3 (4) Genitalöffnung des Männchen tief, fast rechteckig (Fig. 10), äussere Hinterecken des Genitalsegments sehr breit und gerundet. Teil des Kopfes vor den Augen deutlich weniger als 2× so breit wie lang (Fig. 5). .. .. **A. heegeri Fieb.**

4 (3) Genitalöffnung des Männchen (Fig. 9) flach, äussere Hinterecken des Segments spitzbogig, ihr Innenrand im Stumpfen Winkel nach innen führend. Teil des Kopfes vor den Augen deutlich breiter als lang (Fig. 4). .. .. **A. rubescens Noualh.**

5 (2) Rostrum die Spitze der Hinterhüften nicht überragend. Rand des Kopfes vor den Augen stark geschweift (Fig. 1-3).

6 (7) Äussere Hinterecken des Männchen-Genitalsegments breit, eckig, fast abgestutzt, Genitalöffnung tief, fast rechteckig (Fig. 7) .. **A. millierei Mls.**

7 (6) Äusere Hinterecken des Männchen-Genitalsegments schlank, fast spitz, Genitalöffnung breit und flach (Fig. 6+8).

8 (9) Neben der äusseren Hinterecke des Männchen-Genitalsegments sitzt ein abgerundeter Höcker, dessen Innenrand im Rechten Winkel nach innen führt (Fig. 8). Das Rostrum reicht bis zur Mitte der Hinterhüften. Auge sehr klein (Fig. 3), Scheitel 3.0-3.4× so breit wie das Auge .. .. **A. insulare Lindbg.**

9 (8) Hinterecken des Männchen Genitalsegments einfach, ihr Innenrand schräg (Fig. 6). Das Rostrum erreicht die Spitze der Hinterhüften. Auge gross (Fig. 1), Scheitel 2.5-2.7× so breit wie das Auge. **A. arabicum, nov.**

10 (1) Stirnschwiele vorn von den Wangen eingeschlossen **A. breviceps Jak.**

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ON THE APTERYGOTA EXTRACTED BY DR. A. H. EL-KIFL FROM THE CULTIVATED SOIL AT GIZA, EGYPT

(with 1 Text-Figure)

by J. PACLT, Bratislava (Czechoslovakia)

The following list of ten species is based on the material of Apterygota gained from several cultivated fields located in the farm of the Faculty of Agriculture at Giza, west of the River Nile (30° 2' North latitude). The soil samples were taken from a fallow area or under crops in clay loam or light clay soil types, mainly during the period April 1951-March 1952 or during April, 1957 (EL-KIFL, 1957 a, b).

It is a duty to thank Dr. AHMAD HASSANAIN EL-KIFL for the permission to examine his samples.

COLLEMBOLA

1. Hypogastrura manubrialis (Tullb.)

This species have been extracted in numbers at Giza, where, according to STACH (1949), two specimens were kept as early as in 1929.

2. Hypogastrura (Ceratophysella) armata (Nic.)

A few specimens, both adult and young, were found in the collection from Giza.

3. Tullbergia (Metaphorura) sp.

The collection includes five specimens none of which is preserved as well as it can be identified.

4. Proisotoma minuta (Tullb.)

Recorded already from Egypt (Helwan) by STACH (1947). There are numerous specimens in the collection from Giza. These populations include numerous specimens which are devoid of pigment; either totally (then the ocelli are difficult to be observed), or partially (then only the ocelli are pigmented — f. *pallida* Moniez). Many other specimens are quite normal in pigmentation again.

The doubtful species *Isotoma lineata* described by WAHLGREN (1906), from Egypt, may be in the reality *Proisotoma minuta* (Tullb.).

5. Pseudosinella octopunctata (Börn)

Only one specimen was found in the collection from Giza. The species has been described also from Egypt (Cairo) by WAHLGREN (1906), under the name *Lepidocyrtus decem-oculatus*. The species has, as shown in my paper on South African Collembola (PACLT, in litt.), 5+5 eyes to each side. Accordingly, *L. decem-oculatus* Wahlgren becomes a synonym of *P. octopunctata*.

6. Seira (Mesira) squamoornata (Scerbakov.)

According to EL-KIFL (1957a), this species would represent 20% of the Collembola obtained at Giza. This author mentions it under a synonym, *Lepidocyrtus incertus* Handsch. I have seen four specimens of *Seira squamoornata* in the collection sent me for examination. The species has been recorded already from Egypt by WAHLGREN (1906) who identified it as a different species of the genus *Lepidocyrtus*.

DIPLURA

7. Lepidocampa juradoi afra (Silv.)

Two specimens in the collection from Giza are referrable to this form. However, as far as I can see now, most of the members of the subgenus *Lepidocampa* (*Lepidocampa*) should be considered rather as subspecies and individual forms of a single pantropical species, *Lepidocampa weberi* Oudemans. The genus has not been known formerly to occur in Egypt.

8. Anajapyx vesiculosus (Silv.)

There is a single specimen in the collection from Giza which agrees with the modern description of this species as given by SILVESTRI (1938) for his "var. *guineensis*", as well as with the figures of the Italian specimens (SILVESTRI, 1933). Now, the species is known to occur in Italia, Northern Africa (see also PAGÉS, 1953, *Bull. Soc. zool. France*, 77: 475), French Guinea and Madagascar. *Anajapyx mexicanus* Silv., from Cordoba (Mexico), is a little known species, but it might be only a form or a subspecies of *Anajapyx vesiculosus*.

9. Parajapyx condéi (Pagés)

27 well-preserved specimens were found in the collection from Giza, the second known locality of this species. The material on which the original description is based, was collected at Sawaleh, 5 km. South of Fakus, Lower Egypt.

This and the following species were considered by El-Kifl (1957 a, b) for *Heterojapyx* sp.

10. Parajapyx priesneri (Pagés)

Two nymphae about 2 mm. long each were taken at Giza, the second known locality of this species. Terra typica: Sawaleh, 5 km. South of Fakus, Lower Egypt.

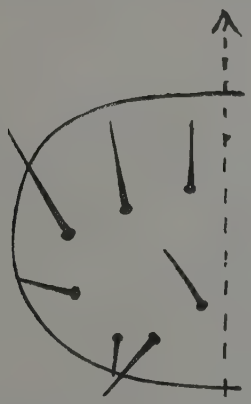

Fig. 1: Pronotum of *Parajapyx priesneri* Pagés, from Giza, Egypt.

Pagés (1953) says: "Pronotum sans s_1 ni s_3", but at least one of the two specimens from Giza is characterized by the presence of s_3 (Fig. 1), remembering thus another Egyptian species — *P. chichinii* Pagés. In other respects, the two specimens from Giza agree well with the description of *P. priesneri* Pagés.

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HONEY PRODUCTION AND COMB FOUNDATIONS

by A. L. EL-DEEB, PH.D.,
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INTRODUCTION

The secretion of wax by the honeybee (*Apis mellifera* L.), which is necessary for the formation of the comb, involves the consumption by the workers of a carbohydrate food such as honey, nectar or sugar syrup. The wax is secreted by four pairs of glands, situated a pair in the ventral side of each of the workers' 3rd. to 6th. abdominal segments. Bees younger than 12 days are incapable of producing wax, probably because of the fact that the wax glands are not yet sufficiently developed and that full development is completed six days later (NELSON, 1926).

It has been stated by several workers (ROOT, 1947, and WEDMORE 1945, et al.) that the formation of one pound of wax will need a raw material ranging from 5-25 pounds of honey. This very wide variation in the amount of honey required was reported to depend on the age of the workers in the colony, because young workers where the glands are at their maximum efficiency would secrete more wax from comparatively little amount of honey than older workers with degenerate glands. The season in which these experiments are made is a deciding factor as it is well known to have some bearing on the amount of wax secreted. Honey gathering and wax secretion (comb building) are two processes which proceed simultaneously and comb building will cease completely when the former comes to an end.

The Egyptian market is heavily supplied with comb foundation sheets of different makes with the aim of saving much of the honey used in the process of beewax making. The primary aim of this paper is to find out whether such sheets serve their purpose compared with those which have been made in the laboratory of the College from pure beewax.

METHODS AND TECHNIQUE

Four experiments were carried out where pure beewax foundations manufactured at Faculty of Agriculture (University of Alexandria), Egyptian comb

foundations circulating in the market, no comb foundation, and drawn combs, were used, respectively. The experiments were carried out during the clover honey-flow of 1957 and 1958 at the University farm in the suburbs of Alexandria. Twenty colonies of Egyptian honeybee (*Apis mellifera fasciata* L.) in Langstroth hives were selected. They were approximately equal in density, brood, honey and pollen stores, and queen age. These colonies were divided into four groups of five colonies each. Thus, five colonies were involved in each experiment. The four groups were used in the four representative experiments.

Kilograms gain in weight of honey and wax (16th May – 12th June, 1957)

Colony number	Experiment I		Experiment II		Experiment III		Experiment IV	
	Beewax foundation		Market foundation		No foundation		Drawn comb	
	Honey	Wax	Honey	Wax	Honey	Wax	Honey	Wax
1	11.12	0.181	4.25	0.679	5.81	0.691	9.65	—
2	8.75	0.118	3.98	0.754	5.32	0.617	10.36	—
3	11.20	0.175	5.20	0.685	5.65	0.649	9.79	—
4	10.82	0.162	4.79	0.713	4.22	0.732	8.95	—
5	9.82	0.154	4.84	0.727	5.30	0.593	10.23	—
Total	51.71	0.790	23.06	3.558	26.30	3.282	48.98	—
Mean	10.34	0.158	4.61	0.712	5.26	0.657	9.80	—

Kilograms gain in weight of honey and wax (10th May – 12th June, 1958)

Colony number	Experiment I		Experiment II		Experiment III		Experiment IV	
	Beewax foundation		Market foundation		No foundation		Drawn comb	
	Honey	Wax	Honey	Wax	Honey	Wax	Honey	Wax
1	7.88	0.102	2.81	6.648	3.87	0.365	6.12	—
2	5.83	0.136	2.17	0.452	3.50	0.484	5.86	—
3	7.77	0.112	3.96	0.437	3.54	0.402	7.55	—
4	7.67	0.141	2.64	0.516	3.21	0.412	5.85	—
5	6.30	0.103	2.61	0.632	3.39	0.504	6.56	—
Total	35.45	0.598	14.19	2.685	17.51	2.167	31.94	—
Mean	7.09	0.119	2.84	0.537	3.50	0.433	6.39	—

In order to estimate the amount of honey or wax added to every colony in each of the four experiments, the frames were weighed: (1) before being used, (2) after the foundations were drawn built and filled with honey, and (3) after the honey was extracted from the combs.

DATA ON THE AMOUNT OF HONEY AND WAX IN THE FOUR EXPERIMENTS

The previous data reveal that the highest yield of honey was produced by colonies supplied with pure beewax foundations, followed by colonies supplied with full drawn combs. There is no point of comparison at all between the honey yield in the previous two experiments and in the other two where market foundations and no foundation were used, because the difference is remarkably significant. The difference between experiments II and III is very slightly significant.

The mean of honey extracted from the colonies of pure beewax foundations was 10.34 and 7.09 kgs. during 1957 and 1958, respectively, with a drop of 31.43 per cent. The colonies of full drawn combs gave 9.80 and 6.39 kgs. of honey during 1957 and 1958, respectively, with a drop of 34.78 per cent. In fact, the last mentioned should have given more honey than the former colonies, but this situation is fairly justified for some reasons explained in the discussion. The colonies of no comb foundation, gave on the average 5.26 and 3.50 kgs. of honey in 1957 and 1958, respectively, while those of market comb foundation gave on the average 4.61 and 2.84 kgs. of honey in the two years, respectively.

By comparing the results in experiment III and I it may be noticed that the colony consumed 5.08 kgs. of honey to produce 0.657 kg. of wax in 1957, while in 1958, 3.59 kgs. of honey were consumed to produce 0.433 kg. of wax. On the average, one kilogram of wax was formed by the consumption of about 7.9 kgs. of honey.

On the other hand, in case of the market comb foundations, the bees consumed 5.78 kgs. of honey to produce 0.712 kg. of wax in 1957, while in 1958, 4.25 kgs. of honey were consumed to produce 0.537 kg. of wax. The average consumption of honey during the two years was 4.33 kgs. of honey for producing 0.54 kg. of wax, in case of no foundation wax, and 5.02 kgs. of honey for producing 0.625 kg. of wax in case of the market comb foundations.

DISCUSSION

The previous data show that almost half of the honey crop of Alexandria region is lost because of using market comb foundation, which we assume that it is not made of pure beewax. The observations show that using market comb foundations brings about more losses than using no comb foundations at all. This is because the amount of honey used in the first case is higher than in the other case; the amount of wax added to the market foundations is higher.

It may be reasonable to suggest that the market comb foundations are made up of a mixture of beewax and another kind of wax such as paraffin wax. The latter

being much cheaper, on the average would be more profitable to the manufactures than using another kind of wax. This evidence is supplemented by results of the melting point which was found to be 65°C, while that of the corresponding beewax foundation is 63°C. Experiments in the laboratory showed that an equal mixture of hard paraffin wax 68°C and beewax (melting 63°C) had a melting point of 65°C which is that of the market comb foundations. The losses involved in using the market foundations are attributed to their property of being non stretchable. The bees being unable to make use of these comb foundation will have to build a comb over it using more wax for constructing the bottom of the cells on both sides. The unchecked circulation of these foundations in the market is encouraged by the fact that the beekeeper does not know the fact so far, and seems to be interested in its low price. In addition to the market losses in honey yield due to the use of these foundations, the consequences of not removing them from the market will be far reached because old combs are melted again to be reused and this process will, in the long run, lead to complete disappearance of pure beewax from the market. The following experiment was made in order to show how fast the different foundations are drawn:

Half pure beewax foundation and half market comb foundation were fixed side to side in a frame. This frame was inserted in a hive. It was found that the former half was drawn by the bees in 18 hours, while the latter was found untouched.

The use of pure beewax foundations, compared with full drawn combs, is not found to affect the honey storing as generally believed; the young workers draw the cells of the foundation, while the older ones gather the nectar and pollen. Moreover, the workers and the queen usually find it easier to work in the newly built combs.

In case of using full drawn combs it was found that these colonies gave less honey than those colonies of pure beewax foundations. This may be due to the fact that the drawn combs were somewhat old, dark in colour, their cells were narrow and holding little quantities of honey compared with new cells. This may lead to gross loss in the density of the colony because the queen will meet great difficulty in finding suitable cells in which she lays her eggs.

As to the colonies of no foundations, although the workers did not lose time in building their combs as they needed during the honey flow, they consumed on the average 7.94 kgs. of honey to produce one kilogram of wax, causing a loss in the honey production.

SUMMARY

Experiments carried out during the clover honeyflow of 1957-1958 consistently showed that one kilogram of wax needs a raw material of approximately eight kilograms of honey. Reports that from 5-25 kilograms of honey are required did

not seem to take into account the worker's age and the season during which the experiments were carried out.

Comb foundations in Egyptian market which are supplied with the aim of saving honey consumed by bees in producing wax were found to cause more honey losses than using no foundation sheets. They were found to be unstretchable by bees; laboratory tests showed that they are made of an equal mixture of paraffin and beewax.

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STUDIES ON THE DISTRIBUTION, BEHAVIOUR, FEEDING HABITS AND CONTROL OF *MICROCEROTERMES DIVERSUS* SILV. ATTACKING LIVE PLANTS IN SAUDI ARABIA

(*Isoptera : Metatermitidae*)

by MOHAMED AL-SAYED AYOUB, B.SC.,

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The presence of a live plant eating termite widely spread in the fields and orchards in Saudi Arabia, has been uncovered by the present writer in 1955.

IDENTIFICATION. — Samples have been identified by Dr. T.E. SNYDER of the Bureau of Entomology (U.S.A.) and by Ch. NOIROT of the Faculty of Science of Paris, as *Microcerotermes* sp.. Other samples examined by W.V. HARRIS, the termite specialist of the Entomological Institute of the Natural History Museum of London, proved they belong to *Microcerotermes diversus* Silv.

This termite is known locally under the Arabic names of "ribia" or "karda", meaning "cutter". To distinguish it from dead wood eating termites, the writer suggests to call it the Hedjazi or Arabian termite.

Due to the present unsurmountable difficulties of studying its life-history in the nest, only its distribution, behaviour, habits and control methods could be studied during the past three years.

DISTRIBUTION. — *Microcerotermes diversus* Silv. has been reported from Mesopotamia, Iraq and India. Insect survey carried out during 1955-1958 in Saudi Arabia disclosed the presence of its colonies in Qizan, Wady Kholais (Jeddah), Arafat (Mecca), Medina, Al-Kharj and Riyadh in the Saudi Arabia. Infested cotton plants from San'a (Yemen) and Hadramut were also received by the writer. *Microcerotermes diversus* is, thus, established in the Southern part of the Arabian Peninsula where the temperature ranges between 18 to 41°C. and the average relative humidity between 33 to 82%. The highest altitude in which this termite existed was at Medina (2000 ft.). *Microcerotermes diversus* is, therefore, a tropical species.

COLONY. — Like other species of termites, *Microcerotermes diversus* lives in underground populous and highly organized colonies. In ascending above the surface of the soil, the workers make characteristic earth runs to protect themselves from sun-light and from their natural enemies.

The colony consists of a fecundative royal couple (sexual male and female), infertile workers and soldiers, and nymphs (young ones) of different ages and sizes which are destined to be the males and females of future colonies; they gradually develop into winged forms and come out of the nest. After a flight, they lose their wings, fall to the ground and each couple burrows into the soil to form a new colony. Although these termites live in the dark in their underground nests at a maximum depth of 30 cms., or in their earth-runs, yet they are forced to come out of their nests and ascend to about 10 cms. up the stems of plants after heavy watering or following heavy rains.

The nests are built in fine silty soil rich in humus, never in poor sandy soil.

FEEDING HABITS. — *Microcerotermes diversus* attacks almost all sort of vegetables, nursery and young living trees and plants and is responsible for considerable damage to agriculture in Saudi Arabia and other infested regions. It attacks mainly healthy living plant tissues and thus differs from most other termites which attack dead wood. It eats the cortex and the pericycle of the vascular bundle of the root and neither attacks the xylem nor the phloem so long as the plant is alive; but after death of the plant, it is compelled to attack the dead wood.

Microcerotermes diversus, though polyphagous, has preference to certain host plants. It feeds on the following plants in Arabia:

Tamaricaceae: *Tamarix orientalis* (Tamarisk.) — Casuarinaceae: *Casuarina equisetifolia* (She-Oak). — Rosaceae: *Rosa* sp. (Roses), *Prunus persica* (Peach), *Prunus armeniaca* (Apricot), and *Pyrus malus* (Apple). — Punicaceae: *Punica granatum* (Pomegranate). — Myrtaceae: *Psidium guajava* (Guava tree). — Malvacea: *Gossypium arboreum* (Cotton), and *Hibiscus esculentus* (Bamia). — Vitaceae: *Vitis vinifera* (Grapevine). — Solanaceae: *Capsicum annuum* (Sweet pepper), *Solanum melongena* (Egg-plant), and *Lycopersicum esculentum* (Tomato). — Leguminoseae: *Acacia flava* (Acacia), and *Tamarindus indica* (Tamarind tree). — Palmae: *Phoenix dactylifera* (Date palm). — Rhamnaceae: *Zizyphus spina-christi* (Nabk tree). — Gramineae: *Zea mays* spp. (Maize). — Rutaceae: *Citrus* sp. (Citrus trees). — Meliaceae: *Melia azadirachta* (Persian lilac).

But its host preference goes to Tamarisk, Casuarina, Roses, Peach, Apple, Pomegranate, Guava, Cotton, Pepper, Tamarind, Date palm, and Grape vines.

The Tamarisk bushes which grow wild in the Wadys in the Saudi Arabia are the main host plant of *Microcerotermes diversus*.

SUSCEPTIBILITY OF FRUIT TREES TO TERMITE ATTACK. — Young susceptible nursery trees are mostly attacked in their first year growth and are killed, while less damage is caused to two-year old trees and practically no harm occurs in the

three-year old trees. Protection of trees during the first and second years will, therefore, help the trees to resist further attacks.

CONTROL. — Agricultural and insecticidal experiments carried out to control *Microcerotermes diversus* gave the following results:

(1) Heavy watering caused mortality of fairly big numbers of termites but did not prevent new outbreaks.

(2) Soil hoeing and exposure of dug up ground gave results similar to heavy watering.

(3) Insecticidal control with arsenical and fluorine compounds and organic phosphorous compounds were ineffective.

(4) Paradichlorobenzine PDB was effective but expensive and, although it has no residual effect, yet it was harmful to young trees.

(5) Chlorinated hydrocarbon insecticides, viz. DDT, Benzine Hexachloride (666) Aldrin were effective in checking the activities of *Microcerotermes diversus* for at least three years, applied in the form of emulsions or wettable powders with the irrigation water at the rate of 2 lbs. of technically pure Aldrin and 9 lbs. technical DDT and 2 lbs. Gamma BHC per acre.

COSTS. — Costs were estimated for large scale treatments including chemicals and labour at 49, 54 and 101 Saudi rials with Aldrin, DDT and Gamma BHC, respectively.

TIMING OF INSECTICIDAL APPLICATIONS. — In coastal regions which are warm in winter and hot in summer, best results are obtained by insecticidal applications during the period from March till November. In tropical regions which are cold in winter and yet hot in summer, treatment during the period from May till September gave very satisfactory results.

NATURAL ENEMIES. — The indigenous and the migratory hoopoes, *Upupa epops major* and *Upupa epops epops*, respectively, feed voraciously on *Microcerotermes diversus* by picking them out from the soil. These birds are present in big numbers in Southern Tahama (coastal region between Jeddah and Yemen), but are only found in small numbers in the interior.

The red ant, *Camponotus* sp., is also a dreadful natural enemy of this termite.

FURTHER INVESTIGATIONS. — A long-term program for further investigations to contribute to the present results has been laid down and its execution commenced in December 1958 in the estates of Sheikh IBRAHIM AL GAFALY. The program includes biological studies and tests of new insecticides which are not phytocidal.

ACKNOWLEDGMENT

The writer expresses his thanks and deepest gratitude to Sheikh AL SADEK DIKHALY, big land owner and farmer at Wady Kholais, who has kindly and gene-

rously given very valuable assistance in carrying out this investigation on his farms and in supplying some of the insecticides which were needed and which he has imported by air at his own expenses. Mr. FOUAD EL-MISTIKAWI has also kindly supplied quantities of Chlordane as a present. Thanks are also due to Mr. FATHY SHALABY, who has kindly helped in sending samples of the termite for identification abroad, and to Professors HARRIS, SNYDER, GRASSI and NOIROT who have taken the trouble of identifying the material submitted.

My Professor, Mr. MOHAMED SOLIMAN EL-ZOHEIRY, President of the Entomological Society of Egypt and of the Agricultural Engineers Syndicate, is cordially thanked for revising this paper, giving detailed information af the work undertaken.

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العدد الثالث والاربعون السنة الثانية والخمسون

مجلة الجمعية المصرية لعلم الحشرات

تأسست فى أول أغسطس سنة ١٩٠٧
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